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RESEARCH AS A FINANCIAL ASSET[1]

IT is only in our century that there could be much significance to such a title as "Research as a Financial Asset." This is an industrial century, and, whether we are proud of it or not, we are an industrial people. For some reasons it may be thought unfortunate that so large a proportion of man's energies should be devoted solely to the industries. In some eras we find that there was a predominance of art over industry; in others literature was predominant, in still others war and conquest. Once territorial discovery and acquisition predominated, and now, in our own times, the principles of community interest have so greatly developed that we are accustomed to seeing many people who, instead of directly producing their own necessities of life, are more generally producing some one little article which contributes in the lives of others. This we recognize as a natural tendency to a higher efficiency. Our intricate and delicately balanced system of work is becoming continually more complex, but is certainly still covered by the elemental laws of demand and of survival. New discoveries in our day are largely mental, instead of geographical, and the old battles of conquest have become wars with ignorance. They are struggles to overcome inefficiencies, attempts to broaden the common mental horizon, as our ancestors broadened their physical horizon. Very few people realize the rapidity with which

[1] Presented before the Congress of Technology at the fiftieth anniversary of the granting of the charter of the Massachusetts Institute of Technology.

technical advances are being made. Few realize how the way of this advance has itself advanced. I might make this more clear by an illustration.

Consider for a moment the increasing uses of chemical elements and compounds. New combinations in alloys, medicines, dyes, foods, etc., and new uses and new materials, are being produced daily. For a more simple comparison, consider only the advances in our technical uses of the metallic chemical elements.

Copper, iron and five other metals were known and used at the time of Christ. In the first 1,800 or 1,900 years of our era, there were added to the list of metals in technical use (pure or alloyed) about eight more, or a rate below three a century. There has been so much industrial advance made within the past twenty to thirty years that fourteen new metals have been brought into commercial use within this period. This is almost as many in our quarter century as in the total preceding age of the world. Of course this rate, as applied to metals, apparently can not continue, but there is no reason to question the possibility of the general advance it indicates. For centuries a single metal was made to serve for all uses which that metal could fill. Then two metals divided the field, each being used where it was preferred for any reason. Alloys began to displace metals to a limited extent. While the engineer still uses iron for his railroad, iron for his buildings and iron for his tools, these irons are different and have been specially developed for those uses. The electrical engineer prefers copper for his conductor, certain irons for the frames of apparatus, other special irons and steels for the shafts, the magnetic fields, etc., and the specialization to best meet specific wants is still under way. I suppose that this kind of complex development is largely responsible for research laboratories.

A research laboratory is a place where men are especially occupied with new problems, presumably not too far in advance of technical application. By this group devoting its entire attention to the difficulties of realizing already well defined necessities, or of newly defining and realizing together, the efficiency of these processes is increased. Men specially trained for this very purpose are employed and they are usually just as unfitted for successfully manufacturing as those who efficiently reproduce are of discovering or inventing. It is merely an extension of the principle of the maximum efficiency. A man with his entire attention devoted for months or years at a time to the difficulties of a single problem should be better able to reach a solution than the man who can devote only irregular intervals to it. He should then also be the better prepared for a second problem.

A research laboratory is also a place equipped with apparatus especially designed for experimental work. In a busy manufacturing plant, if a foreman has an idea pointing towards an improvement of his product he frequently has great difficulty in finding the time, the necessary idle apparatus, the raw materials and the incentive to try it. In the laboratory all of these are combined and there is added a system of cooperation, of permanently recording results and an atmosphere of research.

The mathematics of cooperation of men and tools is interesting in this connection. Separated men trying their individual experiments contribute in proportion to their numbers, and their work may be called mathematically additive. The effect of a single piece of apparatus given to one man is also additive only, but when a group of men are cooperating, as distinct from

merely operating, their work rises with some higher power of the number than the first power. It approaches the square for two men and the cube for three. Two men cooperating with two different and special pieces of apparatus, say a special furnace and a pyrometer, or an hydraulic press and new chemical substances, are more powerful than their arithmetical sum. These facts doubtless assist as assets of a research laboratory.

When a central organization, such as a laboratory, has access to all parts of a large manufacturing plant and is forced sooner or later to come into contact with the various processes and problems, the various possibilities and appliances, it can hardly fail to apply, in some degree, the above law of powers.

As a possible means of illustrating the almost certain assistance which one part of a manufacturing plant may give another when they are connected by experimenting departments or research laboratories, and how one thread of work starts another, I will briefly review part of a single fairly connected line of work in our laboratory. In 1901 the meter department wanted electrically conducting rods of a million ohms resistance. These were to be one quarter inch diameter by one inch length. In connection with this work we had to become fairly familiar with published attempts at making any type of such high resistances. Some kind of porcelain body containing a very little conducting material seemed a fair starting formula after the resistance of almost all kinds of materials had been considered. Our own porcelain department was of a great help in showing us how to get a good start. We learned how and what to mix to get a fair porcelain, and we found that small quantities of carborundum or of graphite would give us the desired resistance about once in a hundred trials. The rods could be made, but the variation of their resistance when taken from the porcelain kiln and when they were made as nearly alike as we could make them, was often so many thousand fold that something new had to be done to make a practical success. A small electric furnace was then devised for baking the rods and this was so arranged that the rate of rise of temperature, the maximum temperature reached and the duration of heat at any temperature was under control and was also recorded. The desired result was obtained and this work was thus finished. It gave us a certain stock of knowledge and assurance.

At that time a very similar problem was bothering one of the engineering departments. Lightning arrester rods, part of the apparatus for protecting power lines from lightning, were needed. Their dimensions were $\frac{3}{4} \times 6$ inches and they needed to have a definite but, in this case, *low* resistance, and could apparently not be baked in a porcelain kiln. The necessary variations in such a kiln are so great that in practise many thousand rods were repeatedly fired and afterward tested to yield a few hundred of satisfactory product. All the cost of making an entire batch would have to be charged against the few units which might be found satisfactory, and in many cases there were none good in a thousand tested. It was evident that regulation and control of temperature was necessary. This was found to be impracticable in case any considerable number were to be fired at one time, as the heated mass was so great that the rods near the walls of the retort received a very different heat treatment from those near the middle and were consequently electrically different. This was still the case even when electrically heated muffles were used. This difficulty led to experiments along the

line of a heated pipe, through which the rods could be automatically passed. Some time was spent in trying to make a practical furnace out of a length of ordinary iron pipe, which was so arranged as to carry enough electric current to be heated to the proper baking temperature. Troubles here with oxidation of the iron finally led to substitution of carbon pipes. This resulted in a carbon tube furnace, which is merely a collection of six-foot carbon pipes, embedded in coke powder to prevent combustion, and held at the ends in water cooled copper clamps, which introduce the electric current. By control of this current the temperature could be kept constant at any point desired. When this was combined with a constant rate of mechanical feed of the air dried rods of porcelain mixture, a good product was obtained. For the past seven years this furnace has turned out all the arrester rods, the number produced the last year being over 100,000 units.

In this work we were also forced to get into close touch with the electroplating department. The rods had to be copper plated at the ends, to insure good electrical contact. The simple plating was not enough. This introduced other problems, which I will pass over, as I wish to follow the line of continuous experiment brought about, in part, at least, by a single investigation. The electric furnace consisting of the carbon tube packed in coke was a good tool for other work, and among other things we heated the carbon filaments for incandescent lamps in it. We were actuated by a theory that the high temperature thus obtainable would benefit the filament by removal of ash ingredients, which we knew the ordinary firing methods left there. While these were removed, the results did not prove the correctness of the theory, but rather the usefulness of trying experiments. It was found by experiment that the graphite coat on the ordinary lamp filament was so completely changed as to permit of a hundred per cent. increase in the lamp life or of a 20 per cent. increase in the efficiency of the lamp for the same life, so that for the past four or five years a large part of the carbon lamps made in this country have been of this improved type. This is the metallized, or Gem lamp. Naturally, this work started a great deal of other work along the lines of incandescent lamp improvement. At no time has such work been stopped, but in addition to it, the new lines of metallic filament lamps were taken up. In fact, during the past five or six years, a very large proportion of our entire work has been done along the line of metallic tungsten incandescent lamps. In this way we have been able to keep in the van of this line of manufacture. The carbon tube furnace has been elaborated for other purposes, so as to cover the action under high pressures and in vacuo. Particularly in the latter case a great deal of experimental work has been carried out, contributing to work such as that connected with rare metals. In such a furnace, materials which would react with gases have been studied to advantage. Our experience with the metallized graphite led to production of a special carbon for contact surfaces in railway signal devices, where ordinary carbon was inferior, and suggested the possibility of our contributing to improvements in carbon motor generator brushes. On the basis of our previous experience and by using the usual factory methods, we became acquainted with the difficulties in producing carbon and graphite motor brushes with the reliability and regularity demanded by the motor art. Furnace firing was a prime difficulty. Here again we resorted to special electrically heated muffles,

where the temperatures, even below redness, could be carefully controlled and automatically recorded. This care, aided by much experimentation along the line of composition, of proportionality between the several kinds of carbon in the brush, etc., put us into shape to make really superior brushes. The company has now been manufacturing these for a couple of years, with especial reference to particularly severe requirements, such as railway motors. In such cases the question of selling price is so secondary that we can and do charge liberally for delicacy and care of operation in the manufacture.

This carbon work naturally led to other applications of the identical processes or materials. Circuit breakers, for example, are now equipped with a specially hard carbon contact, made somewhat as motor brushes are made.

It is not my intention to connect all of the laboratory work to the thread which seemed to connect these particular pieces of work, but rather to show the possible effect in accumulating in a laboratory, experiences which should show on an inventory.

Among other considerations which appeal to me is one which may be worth pointing out. Probably almost every manufacturing plant develops among its workmen from time to time, men who are particularly endowed with aptitude for research in their line. They are usually the inventors of the company. They are often discovered in spite of opposition. They are always trying new things. They are almost of necessity somewhat inefficient in the routine production. In many plants they are merely endured, in a few they are encouraged. In my mind their proper utilization is a safe investment. A research laboratory assists in such a scheme. Sooner or later such a laboratory becomes acquainted with this type of men in a plant and helps them in the development of their ideas.

It is not a perfectly simple matter to measure the value of a research laboratory at any one time. In the minds of some, the proper estimate is based on the money already earned through its work, which otherwise would not have been earned by the company. This is a fair and conservative method which in our generation ought to be satisfactory when applied not too early to the laboratories. It does not take into account what we may call the goodwill and inventory value, both of which should be more rapidly augmenting than any other part of a plant. The experience and knowledge accumulated in a general research laboratory is a positive quantity. In our own case we expended in the first year not far from $10,000, and had little more than expectations to show for it. Our expenses rapidly rose and our tangible assets began to accrue. Perhaps I can point to no better criterion of the value of a research laboratory to our company than the fact that its force was rapidly increased by a company which can not be particularly interested in purely academic work. Our annual expenditures passed the $100,000 mark several years ago. My own estimate of the value would probably be greater than that of others, for I am firmly convinced that proper scientific research is demanded by the existing conditions of our technical age.

Without going into exact values, which are always difficult to determine, consider for a moment the changes which incandescent lighting has witnessed in the past ten years. In this field our laboratory has been active, in contributing to both carbon and to metallic filaments. Moreover, all of the improvements in this field have been the product of research laboratories of trained

men. In the case of our metallized carbon filament, which has now been in use several years, the efficiency of the light was increased by about twenty per cent. Among the carbon lamps of last year these were sold to the extent of over a million dollars.

A broader, but perhaps less accurate impression of changes recently produced, may be gained by considering the economy now possible on the basis of our present incandescent lamp purchases in this country and that which would have resulted if the lamps of only ten years ago were used in their stead. On the assumption that the present rate of lamp consumption is equivalent to about eighty million 25 watt tungsten lamps per year, and on the basis of one and a quarter watts per candle power as against 3.1 of the earlier lamps and charging power at 10 cents per kilowatt hour, we get as a result a saving of $240,000,000 per year, or two thirds of a million per day. Naturally, this is a saving which is to be distributed among producers, consumers and others, but illustrates very well the possibilities. It is interesting to note that we are still very far removed from a perfect incandescent illuminant, when considered from the point of view of maximum theoretical light efficiency.

I see from advertisements that 65,000 of the magnetite arc lamps, originally a product of the laboratory, are now in use. These must have been sold for something near $2,000,000. The supplying of electrodes, which we make and which are consumed in these lamps, should amount to about $60,000 per year.

Our study of the properties of the mercury arc produced our rectifier, which has been commercially developed within the past few years. Of these, about 6,000 have been sold. As they sell for not far from $200 per set, it is safe to say that this also represents a sale of over a million dollars. The advantage of these outfits over other available apparatus must also be recognized as not far from $200 for each hour through which those already sold are all operating.

In such a complex field as insulations and molded materials there have been many changes produced. As far back as 1906 we were using annually, in a certain apparatus, 30,000 specially drilled and machined soapstone plates, which cost $1.10 each. As the result of experiments on substitutes for such material, it was found that they could be molded by us in the proper shape, with holes in place and of a material giving increased toughness, at a greatly reduced cost. As the result of this fact, the price of the purchased material was reduced to us from $1.10 to 60 cents which in itself would have paid for the work. But further developments proved that the new molded material could be made for 30 cents, which the foreign material could not equal, so we have since produced it ourselves. This caused a saving of approximately $24,000 annually for this one molded piece. I have heard of other cases where prices to us have gone down, when we have obtained a little promise from our experimental researches.

In considering the research laboratory as a financial asset there is another view which might not be visible at first sight. It is the question of the difference between the value of the useful discovery when purchased from competitors in the business and when made by one's own company. It is not usually pleasant to have to purchase inventions after their value is known, no matter from whom, but to have to pay a competitor for such a discovery is doubly irksome. One is naturally unduly fearful of its value to the competitor, and he, in turn, is overestimating another's power to use it. The purchaser's profit is

apparently limited to the differences between his efficiency of operating it and that of the original owner. A business usually comprises processes of making and selling something at a profit, and study of the making of the most modern, most improved, most efficient, is about as essential as the study of the limits of safe business credits.

I was recently informed by an officer of another large manufacturing company, where much chemical work is done and which established a research laboratory several years ago, that the most important values they got from their laboratory was the assurance that they were keeping ahead and are at least prepared for the new, if they can not always invent it themselves. Incidentally, he said that from one part of their research work they had produced processes, etc., which had saved $800,000 a year. They are at present spending in their several research departments a total of about $300,000 a year.

We hear frequent reference to the German research laboratories and a brief discussion may be in place. For the past fifty years that country has been advancing industrially beyond other countries. Not by newly opened territories, new railroads, new farm lands, new water power cities, but by new technical discoveries. In fact, this advance may be said to be largely traceable to their *apparent* over-production of research men by well fitted universities and technical schools. Every year a few hundred new doctors of science and philosophy were thrown on the market. Most of them had been well trained to think and to experiment; to work hard, and to expect little. The chemical manufactories began to be filled with this product and it overflowed into every other calling in Germany. These well educated young men became the docents, the assistants and the professors of all the schools of the country. They worked for $300 to $500 per year. They were satisfied so long as they could experiment and study the laws of nature, because of the interest in these laws instilled into them by splendid teachers. This condition soon began to make itself manifest in the new-making of things—all sorts of chemical compounds, all kinds of physical and electrical devices. I might say that pure organic chemistry at this time was academically most interesting. Its laws were entrancing to the enthusiastic chemist and consequently very many more doctors were turned out who wrote organic theses than any other kind. What more natural than that organic chemistry should have been the first to feel the stimulus? Hundreds, and even thousands of new commercial organic products are to be credited to these men and to that time. All the modern dye stuffs are in this class. Did Germany alone possess the raw material for this line? No! England and America had as much of that. But Germany had the *prepared men* and made the start.

It seems to me that America has made a start in preparing men for the research work of its industries. For example, it is no longer necessary to go abroad to get the particular training in physical chemistry and electro-chemistry which a few years ago was considered desirable. Advanced teaching of science is little, if any more advanced in Germany to-day than it is in this country. In my opinion the quality of our research laboratories will improve as the supply of home trained men increases, and the laboratories of this kind will be increasingly valuable when analyzed as financial assets. I am certain, too, that the industries will not be slow in recognizing the growing value of such assets. They merely want to be shown.

Probably in most industries there are

what I may call spots particularly vulnerable to research. For example, the efficiency of steam boilers, based upon the heat energy of the coal used and the efficiency of the engine using the steam, are continually being raised. We may expect, until the maximum calculable efficiency is reached, that this advance will continue. The reason is not far to seek. It is a vulnerable spot. Improvement is possible. A small increase in efficiency of a power plant is an ever-continuing profit. Great numbers of steam power plants exist and so inventors are influenced by the fact that new improvements may result in enormous total economies. Every rule of the game encourages them. I can make this clearer by illustrations.

Artificial light is still produced at frightfully poor efficiency. Electric light from incandescent lamps has been greatly improved in this respect, but there is still room for greater economies. It is still a vulnerable spot.

In the case of iron used in transformers, we have another such vulnerable spot. A transformer is practically a mass of sheet iron, wound about with copper wire. The current must be carried around the iron a certain number of times and the copper is chosen because it does the work most economically. No more suitable material than copper seems immediately probable, nor is there any very promising way of increasing its efficiency, but in the iron about which it is wound there is a vulnerable spot. The size of the iron about which the copper is wound may possibly be still much further reducible by improvements in its quality. In other words, we do not yet know what determines the magnetic permeability or the hysteresis of the iron, and yet we do know that it has been greatly improved in the past few years and that it can still be greatly improved.

Let us make this vulnerable point a little clearer by considering the conditions here in Boston. I assume there are approximately 50,000 kw. of alternating current energy used here. Nearly all of this is subject to the losses of transformers. If the transformers used with this system were made more than ten years ago, they probably involve a total loss, due to eddy and hysteresis, of about $1,000 per day, at the ten-cent rate. Transformers as they are made to-day, by using improved iron, are saving nearly half of this loss, but there still remains over $500 loss per day, to serve as a subject for interesting research work.

It should also be noted that Boston uses only a very small fraction of the alternating current energy of this country.

Consider for a moment two references to the sciences and industry in Germany and England. Dr. O. N. Witt, professor in the Berlin Royal Technical High School, reporting to the German government in 1903, says: "What appears to me to be of far greater importance to the German chemical industry than its predominant appearance at the Columbian World's Fair, is the fact which finds expression in the German exhibits alone, that industry and science stand on the footing of mutual deepest appreciation, one ever influencing the other," etc. As against this, Professor H. E. Armstrong, of entirely corresponding prominence and position in England, says of England: "Our policy is the precise reverse of that followed in Germany. Our manufacturers generally do not know what the word research means. They place their business under the control of practical men . . ., who, as a rule, actually resent the introduction into the work of the scientifically trained assistants." If the English nation is to do even its fair share of the work of the world in the future, its attitude

must be entirely changed. It must realize that steam and electricity have brought about a complete revolution, that the application of scientific principles and methods is becoming so universal elsewhere that all here who wish to succeed must adopt them.

So long as motors burn out, so long as subways are tied up by defective apparatus, so long as electric motors run too hot, so long as street cars can catch fire from so-called explosions of the current, so long as the traffic of a whole city can be stopped by a defective insulation or a ten cent motor brush, there will probably be the equivalent of research laboratories somewhere connected with the electrical industries, where attempts will be continually made to improve.

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RECLAMATION OF THE ARID WEST[1]

THE benefits derived by applying science to industry and the still greater benefits that may be expected when all great problems are attacked in the scientific spirit and on the scientific methods are to a certain extent exemplified by the opportunities afforded and results now accomplished in the conservation of the natural resources of the nation.

The reclamation of the arid west is simply one of a number of items of national importance upon whose correct solution by true scientific methods rests largely, not merely the material prosperity of the nation, but, more than this, the perpetuation of free government, and of high standards of individual liberty.

The stability of a republic or democracy, whichever we may term it, rests not upon its wealth, but upon the character of the individual citizen and voter. The greatest commonwealths are not necessarily those having the greatest natural resources, but rather those in which the human units are strong. The strength of the unit, the family or the voter, is not derived from material wealth, but from ability to act and think independently and to exercise that intelligent self-interest which binds him to the great mass of his fellow men. If, for example, he is working in a factory or on a railroad line, he is, of course, interested in keeping his job. Beyond this, he has little concern with the condition of municipal, state or federal affairs. These are entirely too remote to touch him, and if he lives in a tenement, he has no concern beyond paying his rent and getting the most he can for it.

But take this man, indifferent to forms or details of government, and put him upon a 40-acre farm. Assuming that he has reasonable industry and intelligence, his whole view-point of life changes. He is transformed from being more or less of a nomad, shifting from flat to flat, or from town to town, and indifferent to the general welfare. He now becomes a land-owning citizen and voter, interested in every public movement for better roads, better schools, better local government and everything which leads up to the stability of the institutions of the state as upon these rest the value and comfort of his home.

This thought has been most pithily embodied in a statement attributed to Edward Everett Hale where he asks "Whoever heard of a man shouldering his musket to fight for his boarding house?"

The problem of the reclamation of the arid west is being attacked primarily for the purpose, not of making men rich, but

[1] Presented before the Congress of Technology at the fiftieth anniversary of the granting of the charter of the Massachusetts Institute of Technology.

of strengthening the foundations of the state. It is an attempt being made by the federal government almost at the eleventh hour of its opportunities to utilize the waste resources still remaining at its command, and to employ these in such a way as to strengthen local communities and states, and to create in the more remote parts of the country many prosperous communities composed of independent, landowning citizens, each family being resident upon a farm sufficient for its support, and cultivating the soil intensively, under favorable conditions of sunlight and of water supply, such as to produce the largest crop yield per acre, and to bring about the largest individual success.

The people thus placed upon the farms are not merely producers. They not only raise enough to support themselves, and to sell to their neighbors, but indirectly they stimulate all industries. They are large consumers, as well as producers, and it may be said that for every family placed upon an irrigated farm on the desert, there arises the possibility of another family engaged in transportation or in manufacturing in the east or middle west. All parts of the country are thus linked together. The success of the irrigator in the west means larger cotton production in the south, more boots made in Massachusetts, more freight and passenger cars hauled across the continent.

The success already attained in applying scientific methods to this great problem of conservation of the waste resources of the country may be attributable in part at least to the Institute of Technology, and to the instruction there given. The Reclamation Service, organized under the act of June 17, 1902, includes among its principal men and guiding hands many graduates or students of the Institute of Technology.

The training at the institute has been peculiarly effective in building up in the minds of its students a grasp of the larger conditions, and a proper confidence in ability to handle these. The first thing in any undertaking, such as that of studying the resources of a nation, is to gain a comprehensive view of these and to set on foot investigations and measurements in detail such that the conclusions will have direct value and application to the larger problems involved.

With a comprehensive and reasonably accurate review of the conditions to be met, it is then possible to bring to the solution of the problem the principles and methods of engineering and to put into play the constructive ideas which are inseparable from a technologic education.

The great difference between the methods pursued at the institute and those at many of the older institutions appears to lie in this constructive idea in the inculcation of the conception that the great work of life is to initiate and to build on correct lines rather than to simply know what others have done, and to imitate those.

The constructive faculty, the ability to imagine or to picture desirable results, and to turn these into accomplishment by scientific methods is the foundation for success in these larger lines of work.

In the matter under consideration congress in 1888 authorized an investigation of the extent to which the arid lands might be reclaimed. This problem is enormous and its correct solution is fundamental to the future growth and development of the nation, because of the fact that one third of its area is arid. In that third are potentially some of the most valuable lands in the world.

The problem is to obtain water for these lands. This in turn rests upon questions of economics and engineering, in storage

of flood or other waste waters, and in the adjustment of a form of agriculture suited to these conditions. The results already attained show that the lands are not only capable of supporting a large population, but under government auspices many thousands of families have been settled in prosperous homes and a highly desirable class of citizenship has been created in a most sparsely populated part of the country.

As a natural outgrowth of the investigation begun in 1888, the so-called Reclamation Act of June 17, 1902, was passed, setting aside the proceeds from the disposal of public lands for the construction of works for the reclamation by irrigation of the arid and semi-arid lands. It has been held that congress has absolute control over the public lands and of the funds arising from their disposal, and while it might be questionable as to whether the United States could levy taxes, and thus raise money for reclamation, it has been considered that congress could properly create a trust fund derived from the source named. This fund has amounted to over $60,000,000, and is being added to at the rate of six or seven millions a year. It has been invested in the construction of reservoirs, canals and distributing systems, and already twenty-seven projects have been initiated or completed, works having been undertaken in each of the western states and territories.

Over a million acres have been reclaimed, and 14,000 families are receiving water from works built or controlled by the government, under the terms of this act. Reservoirs have been built having a capacity of nearly 5,000,000 acre-feet, that is to say, the water would cover 5,000,000 acres to a depth of one foot. Canals of large size, carrying over 800 cubic feet per second, have been built for a total length of 300 miles, and somewhat smaller canals constructed with a length of a thousand miles including the ditches. There are over 5,000 miles of water courses, also nearly 70 tunnels with a total length of about 20 miles. The smaller structures number over 20,000 including bridges, culverts, headgates, siphons, etc. Nearly 60,000,000 cubic yards of earth have been excavated and 10,000,000 of loose and solid rock.

The principal results, however, are shown in the crop production and although the works are hardly built to a point further than to try out productions it appears that the value of the crops raised in 1910 was nearly $20,000,000. Land values have advanced from practically nothing to one hundred million dollars. These values will continue to increase as the works near completion.

The object, however, as before stated, is not to make men rich, but to make homes for citizens who will preserve the institutions of the country, and to do this without imposing a burden upon the taxpayers. It has been shown how this is being accomplished by the use of the reclamation fund, which is revolving and growing larger and larger, that is to say, as the money comes back from the works completed, it is used over again and is being increased by additions from the disposal of other public lands. Under wise administration the funds should increase and produce larger and larger results in the conservation of the waste waters and the utilization of these in those parts of the United States where rain is infrequent and where the brilliant sunshine can be depended upon nearly every day in the year. It is really the sunlight which is capitalized and made valuable.

The question is frequently asked, why should not the government reclaim the

worthless lands in the east? The answer lies largely in the fact that no other part of the country than the arid west has such wonderful opportunities for crop production, as it does not have the continuous daily sunshine upon which plant life depends. The advantages of the development in the arid region also are greater from the political standpoint, as population is better distributed and is brought nearer to important sources of mineral wealth, enabling development of industries in otherwise remote and inaccessible localities.

All of these results are successful in proportion as they have been brought about by scientific methods, and by following the principles inculcated at the schools of which the Institute of Technology is chief.

F. H. Newell

U. S. Reclamation Service,
Washington, D. C.

THE ST. LOUIS UNIVERSITY EXPEDITION TO COLORADO

In a recent number of the *Fleur-de Lis,* one of the publications of the St. Louis University, there appears an article on a geological expedition to Colorado, organized last summer by that university. Its purpose was to afford an opportunity of geologic field-work to those teachers who were called upon to teach geology as an accessory subject, in addition to other regular work. Accordingly, those who availed themselves of the opportunity were chiefly professors of physics and chemistry. They were: Professor John P. Coony, head of the department of chemistry, St. Louis University Medical School; James I. Shannon and Charles Cloud, professor and associate professor, respectively, of physics, and Theodore Schulte, professor of chemistry, St. Louis University; Joseph Wilczewski and William Agnew, of the department of physics, St. Ignatius College, Chicago; A. M. Schwitalla, professor of chemistry, St. Xavier College, Cincinnati; Vincent Jenneman, professor of physics, Sacred Heart College, Prairie du Chien, Wis.; Hugo Sloctemeyer, curator of the Mineralogical Museum, St. John's University, Toledo, O.

Colorado, and especially the foot-hill region, was chosen for its variety of geological formations within a comparatively small area. Ten days were spent near Cañon City chiefly to study the occurrence and formation of igneous and metamorphic rock in the Royal Gorge of the Arkansas River. Camp was then moved to Garden Park, ten miles north, where during four days attention was principally directed to the foot-hill topography and the strata profiles in Oil Creek Cañon. The famous dinosaur beds of the region were also examined as carefully as was possible under the circumstances. Finally, more than two weeks were spent in the Ute Pass near Manitou, where, besides special problems investigated by the individual members of the party, some coordinated work was done on the formations of the Manitou embayment, and the Archæan-Cambrian contact in this region. The pedagogical character of the work was continually kept in mind, and the results were such as to warrant a repetition of the experiment.

A. M. Schwitalla

RESOLUTIONS ON THE DEATH OF PROFESSOR CHARLES OTIS WHITMAN

At the Ithaca meeting of the Eastern Branch of the American Society of Zoologists in December, 1910, it was voted that "the president appoint a committee to prepare a resolution on the death of Professor Whitman, the resolution to be published in the minutes of the society, and transmitted to the family of Professor Whitman." In accordance with this vote Professor S. F. Clarke and Professor F. R. Lillie were appointed on this committee. They have prepared the following resolutions which have been incorporated in the permanent records of the society:

The Eastern Branch of the American Society of Zoologists records with profound regret the death of Professor Charles Otis Whitman on December 6, 1910. Professor Whitman was one of the founders of this society; he was chairman

of the committee that issued the first call for organization of the American Morphological Society, the forerunner of the American Society of Zoologists, and he was president of the society for the first four years, 1891–94. He was organizer of the *Journal of Morphology* and its editor for many years, and in this capacity also exerted a strong influence on the development of zoological research in America. As director of the Marine Biological Laboratory for twenty-one years, he exerted an even more powerful and entirely unique influence in the development of biological science. As an investigator he was painstaking, enthusiastic and thorough, as a thinker on biological problems profound and far-sighted. Devoted to principle, his uncompromising personality sometimes made enemies, but the charm of his character made him devoted friends. His influence will long remain as one of the most important forces in the history of zoology in America.

SCIENTIFIC NOTES AND NEWS

JOHN WILLIAM DRAPER, eminent for his contributions to physics, chemistry and physiology, was born on May 5, 1811, and the centenary of his birth is being celebrated by New York University, where he was professor from 1839 until 1873.

THE Paris Academy of Sciences has elected as corresponding members Professor Svante Arrhenius, of Stockholm, in the section for physics, and Professor I. P. Pawlow, of St. Petersburg, in the section of medicine.

As already announced, the British Association will meet at Portsmouth on August 30. On the evening of that day, Sir William Ramsay will give the presidential address. Public lectures will be given by Mr. Leonard Hill on the "Physiology of Submarine Work," and by Professor A. C. Seward on "Links with the Past in the Plant World."

THE Association of German Men of Science and Physicians will hold its eighty-third meeting at Karlsruhe from September 24 to 30.

MR. J. H. GRISDALE has been appointed director of the experimental farm system of Canada, to succeed Dr. William Saunders.

PROFESSOR LOUIS DOREMUS HUNTOON, M.E., of the department of mining and metallurgy, Sheffield Scientific School, Yale University, has resigned his position to engage in work in the Canadian gold fields.

DR. F. W. WOLL, professor of agricultural chemistry in the University of Wisconsin, has been designated as the delegate of the university at the celebration of the centennial of the University of Christiania, Norway, September 2 to 6, 1911. Dr. Woll is a graduate of the University of Christiania.

PRESIDENT TAFT has appointed the following as the official representatives of the respective bureaus of the federal government on the organizing committee of the International Congress of Applied Chemistry: *Department of the Treasury*—Dr. Reid Hunt, Hygienic Laboratory, Marine Hospital Service; Dr. A. B. Adams, Internal Revenue Service. *Department of the Interior*—Mr. George Seiger, Geological Survey; Dr. George S. Ely, Patent Office; Professor Nathaniel W. Lord, Ohio State University, Columbus, O., to represent Bureau of Mines. *Department of Agriculture*—Dr. H. W. Wiley, Chief, Bureau of Chemistry; Dr. C. F. Langworthy, Office of Experiment Stations; Professor W. W. Cooke, Biological Survey; Mr. William L. Hall, Forest Service; Dr. Frank E. Cameron, Bureau of Soils; Professor W. J. Humphreys, Weather Bureau; Dr. R. H. True, Bureau of Plant Industry; Dr. Marion Dorset, Bureau of Animal Industry; Dr. W. F. Hillebrand, Chief Chemist, Bureau of Standards.

PROFESSOR K. L. HATCH, of the University of Wisconsin, has been elected president of the newly founded American Association for the Advancement of Agricultural Teaching in Secondary Schools, which was launched in Chicago at a meeting of all the heads of departments of agricultural education in the universities and colleges in the north central states. Representatives from the United States Department of Agriculture were also present. The purpose of the new society is to organize and systematize agricultural material so that it can be used with greater efficiency in propagating agricultural education through the medium of the high schools of the nation.

Mr. K. F. Kellerman, physiologist in the Bureau of Plant Industry, Washington, sailed for Europe on April 25 and will spend three months in a study of the progress being made in the investigation of soil bacteriology in Germany, Russia, France and England.

Dr. Charles B. Robinson expects to return to this country about the end of July. Dr. Robinson has been in the service of the Philippine Bureau of Science for over three years and it is understood has been collecting this spring along the Indo-China coast, a region very little known botanically.

On April 27 Professor R. W. Wood, of the Johns Hopkins University, began a course of three lectures at the Royal Institution on "The Optical Properties of Metallic Vapors," these being the Tyndall lectures.

Sir John Murray lectured before the New York Academy of Sciences on April 24, his subject being "The Depths of the Sea." On April 27 he lectured before the Geographical Society of Chicago on "The Ocean." After the lecture the Helen Culver gold medal of the society was conferred upon him.

Dr. Jacques Loeb, of the Rockefeller Institute for Medical Research, delivered the address at the annual conversational meeting of the Philadelphia Pathological Society, on April 27. His subject was "Fertilizing Effects of the Extracts of Tissues, Blood and Sperm." After the address a reception was given to Dr. Loeb at the University Club.

Professor Lafayette B. Mendel, of the Sheffield Scientific School, Yale University, gave two lectures on "Nutrition" at Goucher College, Baltimore, on April 27 and 28.

Professor E. L. Mark, director of the zoological laboratories of Harvard University, gave an illustrated lecture before the departments of geology and biology of Colgate University on the evening of April 21. His subject was "Some Vestigial Organs in Man."

Dr. Maximilian Toch, head of the firm of Toch Brothers, manufacturers of paints, will give three lectures before the students of the Engineering School of Columbia University, on "Paints, Pigments and Drying Oils." Dr. Toch was at one time assistant professor in Columbia.

Professor G. W. Ritchey, of the Mount Wilson Solar Observatory, at Pasadena, Cal., gave a public lecture under the auspices of the University of Minnesota Chapter of the Sigma Xi on April 21 on the subject "The Largest Telescope in the World and its use in Photographing the Heavens."

Professor Svante Arrhenius, Stockholm, Sweden, will deliver the third Weir Mitchell lecture of the Philadelphia College of Physicians on May 16. The subject will be "The Passage of Microorganisms through Interstellar Space: a Theory bearing on the Origin of Life on a Planet."

A life of Mrs. Ellen H. Richards is to be written with the approval of Professor Richards. It is hoped that the story of her life may be of such a character that it will not only interest those who have known Mrs. Richards either personally or through her work, but will also serve to extend her influence and to inspire future workers. Any material, such as letters, photographs, characteristic sayings and incidents, which will help to show her personality and her interests and activities will be valuable to the editor, Miss Caroline L. Hunt, and should be sent to her at 32 Eliot Street, Jamaica Plain, Mass.

Dr. Charles Stedman Bull, professor of ophthalmology in the medical department of Cornell University, died on April 17, aged sixty-six years.

Mr. T. Rupert Jones, F.R.S., formerly professor of geology at Sandhurst, has died at the age of ninety-one years.

Major George Lamb, director of the Pasteur Institute of India and known for his important work on snake venoms, the plague and hydrophobia, died at Edinburgh on April 11, in his forty-second year.

Professor Eduard Zacharias, director of the Botanical Institute of Hamburg, has died at the age of fifty-nine years.

Professor A. Houzeau, professor of chemistry in the Rouen Scientific School, has died at the age of eighty-two years.

THE eighth annual meeting of the American Society of Tropical Medicine will be held in Tulane University, New Orleans, on May 18 and 19, under the presidency of Dr. William S. Thayer, of the Johns Hopkins University.

WORD has been received from Professor Arthur H. Quinn, secretary of the Association of Colleges and Preparatory Schools of the Middle States and Maryland, that the association accepts the invitation of Columbia University to hold the next meeting there. The meeting will take place on December 1 and 2, 1911.

ON the invitation of the departments of science of Princeton University, the teachers of science in New Jersey schools will hold their annual meeting in Princeton on May 27.

IN a letter to Secretary Walcott, of the Smithsonian Institution, dated Bahia Blanca, Argentina, March 17, 1911, Mr. Bailey Willis gives the following account of the initiation of the work which he is conducting for the Argentine government:

> You may care to know what progress we are making in the forty-first parallel survey, south latitude. We landed in Buenos Aires twenty days ago. The topographers have now been at work a week on base line and station signals in northern Patagonia. Washburne and Jones, geologists, went out to initiate themselves in the geology of a section that has been studied along the railroad that runs west from this city half way to the Andes. Pemberton and I remained in Buenos Aires till yesterday, when we got our outfit aboard the steamer that takes it to Puerto San Antonio in northern Patagonia. Now we are off with 120 mules and horses on a 200-mile ride across Pampa and plateau to San Antonio. The region is almost waterless south of the Rio Negro. We find that there is a basement of gneiss and granite, which comes to the surface here and there. There are porous continental sandstones of Tertiary and Cretaceous ages, and also large areas of basalt. Their distribution is unknown, but in the course of four or five months we shall know it, and the answer to the water problem will be worked out.

IN his recent address at Madison, ex-President Theodore Roosevelt spoke as follows in regard to the University of Wisconsin: "It is not too much to say that the University of Wisconsin occupies a position entirely unique not merely in this country but in the world, as an institution which beyond all others has come the nearest to recognizing the ideals of using the instrumentalities of higher education for rendering the greatest possible service to the country. The nation, as a whole, points to this state as the state in which the leading public men are not backed by the ordinary corporations that too many of our public men have been backed by in the past, but by the greatest educational institution in the state, and I have found everywhere on the Pacific slope and in the Rocky Mountains that the ambition of every state was to follow Wisconsin as the wisest and most far seeing progressive state, and to secure the same cooperation in their state between their government and their university in rendering service to the state, which obtains to-day in Wisconsin."

AT a meeting of executive officers of boards of health of New Jersey, held at Newark, N. J., on April 17, 1911, a permanent organization to be known as "The Health Officers' Association of New Jersey" was formed. A number of the more prominent health officers of the state were present. The objects of the organization are, the advancement of knowledge relating to public health and sanitation and the encouragement of social intercourse among health officials. The following officers were elected:

President—C. H. Wells, Health Officer, Montclair.

Vice-president—John O'Brien, Jr., Health Officer, Plainfield.

Secretary and Treasurer—J. Scott MacNutt, Health Officer, Orange.

An executive committee of seven was elected, and the officers, with the advice of this committee, were instructed to draw up a constitution and by-laws for presentation at the next meeting to be held May 17. The membership at present includes as eligible all health officials holding state board of health licenses, and doubtless will be extended to other health

board officials and employees and members of local boards of health. Five or six meetings a year will be held for the presentation and discussion of papers. Most of the prominent health board officials of the state have expressed themselves as strongly in favor of the association, which promises to grow rapidly in membership and influence.

UNIVERSITY AND EDUCATIONAL NEWS

By the will of Ernest V. Cowell, the University of California receives a bequest of $750,000. It is for a hospital, a gymnasium and an athletic stadium, each to cost $250,000.

The Nebraska legislature has passed a bill, which the governor has signed, appropriating $100,000 with which to begin the development of the campus of the College of Medicine of the university, in Omaha. The issue presented in the legislature was whether or not the state was ready to begin the development of a complete medical college plant, and the decision was affirmative, by a narrow margin in the house and by a wide margin in the senate.

Dr. Elmer Ellsworth Brown, U. S. Commissioner of Education, has been elected chancellor of New York University.

Bruce Payne, Ph.D. (Columbia, 1905), professor of educational psychology in the University of Virginia, has been appointed president of the George Peabody College for Teachers at Nashville. The old Peabody College has been disbanded and President Payne will have a free field in constructing the new one, which is to have new grounds, buildings and faculty, and one million and a half additional endowment.

Professor H. H. Newman, chairman of the school of zoology, University of Texas, has resigned to accept an associate professorship of zoology at the University of Chicago. All appointments in zoology at Texas have been made and the details will be made public in a subsequent number of this Journal.

Dr. Clinton R. Stauffer, assistant professor of geology at the School of Mining, Kingston, Canada, has been appointed associate professor of geology in Western Reserve University.

Dr. J. J. Laub, of Heidelberg, has been appointed professor of theoretical physics and geophysics in the University of La Plata.

DISCUSSION AND CORRESPONDENCE

THE REFORM OF THE CALENDAR

To the Editor of Science: A recent letter by Professor Chamberlin in your journal entitled "Reform of the Calendar" has reinterested me in the subject and suggested the publication of another, and, it is hoped, more correct view of the subject. A perusal of the article "Calendar" in Encyclopædia Britannica will suggest arguments in its favor; as to recent articles on the subject, time and inclination are lacking for their reading and the risk is run of anticipation on conflict.

As the greater part of the eighteen folio pages in the Encyclopædia is under the head "Reformation of the Calendar" or treats of intricate peculiarities calling for reform, the legitimate effect of the article is the conclusion that what is needed and possible is not a reformation, but a

Simplification of the Calendar

Let us then state this as a problem and attempt a solution. The Encyclopædia's definition may be condensed to read "A calendar is a method of meting out time into hours, days, etc., for ordinary use." It is therefore a table of measures which establishes certain units of time and defines the relations between them, and this must be so done as to facilitate the transaction of business.

A fortunate solution must depend largely on the units employed and Professor Woolhouse gives, as he must, the *solar day* and the *solar year* as two natural and indispensable units, mentioning later the *month* as a natural but not indispensable one. Owing to these units being natural, they are incommensurable and simplicity requires the smallest possible number of such units. It would therefore seem advisable to exclude the month from any controlling influence in the calendar.

Let us see how this will look in a more definite and practical form.

Suppose that SCIENCE should found the

Calendar Betterment Association

to spread information and enlist interest and influence sufficient to secure the passage of a law something as follows; similar action to be urged in other countries:

It is hereby enacted that the *calendar year* 1917 shall end and the *new-calendar year* 1918 shall begin at midnight of the thirtieth day of December, 1917.

That a *new calendar* is hereby established requiring:

That the years 1918 to 1924, inclusive, shall consist of fifty-two weeks of seven days each, thus giving these years the uniform length of 364 days.

That during these seven years the twelve months shall be recognized in their customary order and grouped in the usual four seasons, but with a length of thirty days each for the first two months and thirty-one days for the last month of each quarter. Each first month of a quarter will then begin with Monday, the second with Wednesday and the last with Friday, and all thirty-first days will fall on Sunday.

That the dates in existing legal papers, or future ones which may mention months, shall apply to the months of the new calendar, in which the first days of January, February, June, August, September and November will take the place of the suppressed thirty-first days of the preceding months.

That the dates in all legal papers made under this new calendar shall be expressed by stating the day of the week, the number of the week and the year, the weeks being numbered in succession from the beginning thereof and the days of the week from one to seven, or named as usual, from Monday, the first day, to Sunday, the last. When the date is expressed in fractional form the numerator shall be the number, or name, of the day and the denominator that of the week, thus: the first Tuesday in 1918 will be 2/1 1918 or Tu/1 1918, and the last Saturday 6/52 1918 or Sa/52 1918, and the date may be underscored when confusion might occur with an old calendar date. For relatively unimportant purposes these dates may be written thus: 20118 and 65218.

That during the *common years* previous to 1925 the necessary adaptations of business procedure to the occurrence of *long years* of 53 weeks each shall be made.

That as the year 1924 will end about the shortest day, and as certain of the calendar years must be lengthened to make their average the natural length, the year 1925, and every fifth year thereafter, shall be a *long year* of 53 weeks, with the exception of the year 1950 and subsequent years divisible by 50, which shall be common years.

That for a still closer adjustment the years 1995, 2395, etc., at intervals of four hundred years shall be changed back to common years of 52 weeks each.

That no further adjustment is to be anticipated for 25,000 years.

That after 1/1 1925 all legal and business documents shall be dated by the day, week and year, and periods of time shall be stated in days, weeks and years, and that so stated a year shall be held to mean 52 weeks, and that when a year of 53 weeks is intended it must so be stated or the term "*long year*" used.

It was my first intention to write a criticism of the calendar proposed in the letter referred to, but on a visit to an old friend shortly after its publication we discussed it and also my system, which he urged me to put in print. From the point of view of the writer of the letter, which my friend somewhat favored, the calendar he proposes has much to recommend it. It is certainly picturesque, too much so for business purposes, but not enough for ecclesiastical. If the definition of a calendar could be changed to make it a piece of tapestry to decorate the seasons, it might be acceptable in America with publishers of calendars and others on the ground that people here are too practical and lack in artistic feeling, and need something of the kind to educate them to appreciate the beauties of the church calendars, but business people want a plain calendar.

After writing the above an accidental opening of your issue of December 23 shows me a similar proposition for correction by weeks from the University of Illinois, where for some years astronomy was in my charge, but the arrangements proposed bring to mind a passage in the Encylopædia which says: "The difficulties that arose in attempting to" adjust differences "induced some nations to abandon the moon altogether." Wise nations! To the escaping Hebrews the moonlight was all-important, but if we were to run away we should most likely depend on artificial light and may safely abandon the moon.

A discussion in detail of the feasibility of the correction by weeks would be too long for a single letter. My hope is that it may be exhaustively criticized and prove to be the easiest way. One five-yearly correction large enough to be intelligently provided for ought to be better than numerous small and confusing irregularities.

Comparatively such a correction is not large. For the sake of uniformity we now have "standard time" varying as much as two per cent. from local time, local noon varying as much as one per cent. from astronomical, and we have months differing in length by ten per cent., with similarly large differences between the calendars of different nations. The proposed correction is less than two per cent.

Some of the details have been worked out in tabular form to the year 2006 and further, but this letter is long enough without the insertion of tables. The general effect of the proposed calendar on New Year's Day is to shift it towards the shortest day of the year, but by 1946 and 1991 it has returned to its present place; after 1991, however, it creeps back more permanently so as to remain among the shortest days of the year.

J. Burkitt Webb

To the Editor of Science: If calendar reform is going to be a subject of discussion in scientific circles, international conferences, etc., it would be well to bear in mind that any radical change will be a great inconvenience to the business world. I agree with Professor Barton[1] that the disadvantages of Professor Chamberlin's scheme outweigh its advantages.

We can not have an ideal calendar for the reason that 365 is not exactly divisible by 12, 10 or 8. The year has been divided into twelve months for thousands of years, and it is as satisfactory a division as can be made, especially since the twelve months are divisible into four quarters. The chief objection to the present calendar is that February has only 28 days. This can easily be changed by giving it 30, and taking the two days from some of the months that now have 31. I suggest the following:

Five months of 31 days: December, January, June, July, August—155 days.

Seven months of 30 days: February, March, April, May, September, October, November—210 days.

February may be given 31 days in leap year.

December, January and July each have now a national or general holiday. We can shift Memorial Day to June and Labor Day to the last working day in August, so that each month of 31 days would have a holiday in it.

Wm. Kent

The movement for the reform of the calendar has just made new progress. We learn from M. Grosclaude, inventor of the chief project, and also by official confirmation through the newspapers, that the Swiss Federal Council has decided to initiate the calling of an international conference, whose purpose will be the reform of the Gregorian calendar, in order to obviate the inconvenience caused by the changing of the weeks in the year, which brings the school holidays at different times each year.

The Vatican has been consulted and would be in favor of the reform, which would remove the necessity for changing the date of Easter every year.

The reform to be discussed will be based on the project of Grosclaude, which has already been explained in these columns, and which was recommended by the first congress of the Universal Esperanto Association last August.

It is therefore to be hoped that soon this important reform will be on the way to realization.

[1] Science, January 13.

If the Swiss government had not taken the initiative in the matter, the government of the Netherlands was and is yet willing to call a conference for the same purpose.

During the past few months SCIENCE has devoted a great deal of space to the above subject, and several well-developed schemes for improving the calendar have been advanced. However, none of these schemes has been complete, and none of the authors of them has presented with his scheme a plan by which it could be introduced.

The above quotation is a translation from Esperanto of a news item which appeared in the issue for December 5, 1910, of the official organ of the Universal Esperanto Association, published at Geneva, Switzerland. It speaks of a scheme for improvement of the calendar that has been under discussion in Europe for more than twenty-five years, but which, strange to say, has never been published in this country. This plan was originally published anonymously by Camille Flammarian in 1884 and afterwards by M. Armelin, of Paris, in 1887. In 1900 it was revived by L. A. Grosclaude, of Geneva, and it is known as Grosclaude's project. It has been developed to its present stage by scientists of various nations in the *Internacia Scienca Revuo,* published in Dresden, by means of the language Esperanto. In the recent discussion the original plan has been slightly modified in accordance with ideas advanced by Professor Dr. W. Koppen, of Hamburg; and the scheme as here presented is now advocated and supported by Dr. Rene de Saussure, a well-known scientist of Geneva.

As will be seen from the following explanation and the accompanying table, the compilers of this scheme have achieved a wonderful simplification of the Gregorian calendar, which can be introduced with absolutely no break in present dates and no interruption of present customs.

There are just three great evils in the present calendar, and these are: (1) The constant changing of the position of the weeks in the year, (2) the great irregularity and inequality of the lengths of the months, (3) the necessity for movable holidays on account of the changing of the weeks each year.

As the third evil is caused by the first, there are really only two points which need to be changed in the present calendar. These are: (1) To fix the weeks in the year, and (2) to even up the lengths of the months.

As there is just one day more than fifty-two full weeks in an ordinary calendar year, the obvious solution of the problem of the changing weeks is to make this day a non-week-day. Having done this, the fifty-two weeks may be divided into four quarters of thirteen weeks each. As each quarter has ninety-one days, it may be divided into three months—one of thirty-one days, and two of thirty days. A little calculation demonstrates that the logical place for the thirty-one day month is at the beginning of the quarter, as this arrangement makes it unnecessary to change the length of more than five of the months; the other seven months remaining exactly as at present.

By placing the non-week day at the end of the year, it may be made the thirty-first of December, thus remaining a part of the month and of the year, although not a part of any week.

As the thirty-first of December is St. Silvester's Day, and is celebrated quite extensively in some sections in Europe, it is proposed to call the non-week day *Silvester* and to make it the holiday, instead of January first as at present.

As the first day of the week is Sunday, each quarter must begin on Sunday in order to have thirteen complete weeks in each quarter. January first would therefore fall on Sunday, and "Silvester" would come between Saturday and Sunday.

In leap years, the leap-year day would also be made a non-week day and would be placed at the end of the first half-year, thus becoming the thirty-first of June, and giving the first half year the same number of days as the second half. It is proposed to call it *Leap-year Day.*

This plan makes a peculiarly happy disposition of the holidays, movable, as well as fixed, as may be seen by the accompanying

table of fixed dates. It combines all the best points of the proposals that have been published in these columns, and avoids their bad points.

The plan for its adoption has all the simplicity that usually accompanies really good things and is as follows:

In the year 1911, the days of the week in the months of September, October, November and December coincide with the arrangement in the proposed calendar. If, any time during the year 1911, the governments of the various nations will decide to declare the thirty-first of December of that year, and of all future years, a non-week-day, one half of the problem will have been solved. If they will then declare that during the year 1912, and all future years, the number of days in the five months February, March, April, May and August shall be changed in accordance with the accompanying table, the entire problem will have been solved.

As this is a perfectly simple, practical and conservative plan for overcoming difficulties that every one is obliged to contend with every day of his life, steps should be taken by those in a position to do so, to have the president authorized to appoint a commission to investigate the matter thoroughly, with authority to confer with the similar commissions to be appointed by other governments and by the Vatican, to the end that some such scheme shall be adopted.

The conditions necessary for the adoption of this scheme as outlined above will recur in 1917, and as it is hardly likely that any scheme can be agreed upon by December, 1911, we may look to that year to free us from the inconveniences under which we have suffered so long.

John M. Clifford, Jr.

Braddock, Pa.

INVARIABLE TABLE OF DATES

For the Quarters

Days	Months														
	January April July October					February May August November					March June September December				
Sunday.....	1	8	15	22	29	...	5	12	19	26	...	3	10	17	24
Monday....	2	9	16	23	30	...	6	13	20	27	...	4	11	18	25
Tuesday....	3	10	17	24	31	...	7	14	21	28	...	5	12	19	26
Wednesday	4	11	18	25	...	1	8	15	22	29	...	6	13	20	27
Thursday...	5	12	19	26	...	2	9	16	23	30	...	7	14	21	28
Friday.....	6	13	20	27	...	3	10	17	24	...	1	8	15	22	29
Saturday...	7	14	21	28	...	4	11	18	25	...	2	9	16	23	30
Non-week day[1]	...	...	...	...	...	...	...	...	...	...	...	...	...	...	31

[1] Only in December of ordinary years and also in June of leap years.

QUOTATIONS

THE GOVERNMENT OF UNIVERSITIES

Americans interested in the questions of university government will find much that is interesting and pertinent to our own situation in the admirable article on "Modern Universities and their Government" which is the leading feature of the London *Times's* educational supplement for April 4. We are very much in the habit of thinking of our universities, with ultimate power over the institution resting in the lay boards of trustees, as being in this respect quite unlike any other educational institutions of similar importance; and this is natural enough, since the half-dozen new universities that have been established in the chief provincial cities of England, and which are probably their only important analogues, are of such recent origin as to be seldom prominently in our thoughts in this connection. It is the government of these new universities, and especially the methods and the spirit of their procedure in the appointment of professors, that constitute the subject of the *Times* article; a subject justifying the extreme seriousness with which it is discussed because the universities in question are expanding with such rapidity that they "have to a large extent the future of English learning in their hands."

Both the resemblances and the differences that suggest themselves, as between the American and the English experience, are of decided interest. Into the details of the English organization we shall not attempt to enter; suffice it to say that the active governing authority of the university, corresponding to our board of trustees, is what is known as the council; and while this council is not nominally self-electing or self-renewing, in practise it is so. Perhaps the most interesting state-

ment made about the councils is that which refers to the personal attitude of the members who constituted those bodies in the first place, and to the signs of a change which seems to be more or less in danger of showing itself as matters settle down to a more mechanical routine. The large prospect of creative utility which the foundation of the provincial universities opened up attracted the services in their councils of some of the ablest business men in England, who felt that they were privileged to take part in the building of great institutions of national importance. "And, being large-minded men," says the *Times* writer, "they have usually recognized the limits of their own competence, and know what matters to leave in the hands of the experts. They have respected and trusted the scholars by whose presence their cities were enriched." In some of the successors of these large-minded men, a tendency has been observed to depart from this fine attitude. "The smaller man is apt to have less respect for and less trust in the scholar than the bigger man, and a more serene confidence in his own capacity as a 'business man' to deal wisely with any and every question that may come before him."

Speaking broadly, it is safe to say that while our boards of trustees have furnished illustrations of both of these types of attitude and conduct, neither their merits nor their defects have been so pronounced as the *Times* article represents to be the case in England. Many trustees of American universities, however, have done a great amount of important and unselfish service, animated by that same feeling of the honor and the usefulness of their posts as obtained with the able men who helped to build up the new English universities; while, on the other hand, the instances of pretentious or ignorant meddling by trustees have been very rare in this country, in the case of universities of high standing and importance. But this abstention from harmful interference on their part has been accompanied, in most cases, by that abnormal concentration of power in the hands of the university president which has formed so prominent a subject of recent academic controversy.

It is a notable circumstance that, varied as are the methods of selection discussed in the *Times* article, there is not a word of discussion as to the tenure of the professor after appointment. That a professorship should be a life position it does not seem to occur to any one to question. The defects that exist in regard to the matter relate entirely to the way in which the selection is made. In this respect great differences exist; some of the university councils proceeding upon exceedingly crude "business" notions of the way in which the best man is to be found, while others have established methods that are, in the opinion of the *Times* writer, the best that could possibly be devised. In these cases, the most careful inquiry is instituted, in the first instance, by a committee of the particular faculty concerned, an inquiry which results in the adoption of different methods—including, when necessary, that of advertisement—according to circumstances; the senate considers the result of this inquiry, and then makes its recommendation of a particular person to the council, giving "a full and reasoned statement" of the grounds for its choice. Of course, this recommendation is usually adopted without question; but the process, with a council of the right sort, is evidently a wholesome one. It is not altogether different from that obtaining in some of our own universities; but what strikes one in reading of it is the profound realization of the importance of making the best possible choice. This, as well as the permanency of tenure, is sure to have a powerful influence in the preservation of the ideas of dignity and importance which ought to attach to the post of a university professor; and it is evident that in England as well as with us much will depend on the vigor with which, now and in the near future, those ideas are insisted on by the public opinion in the educational world. "Lay hands suddenly on no man," but, having chosen him, let him feel that his position is assured—this is the rule that must guide in professorial appointments if we are to get the maximum of that real

university efficiency which can not be measured by any mechanical tests, but which has its root in the personality of the professors.—*The New York Evening Post.*

SCIENTIFIC BOOKS

A Directory of American Museums. Compiled by Paul Marshall Rea. Being No. 1, Volume X., Bulletin of the Buffalo Society of Natural Sciences. 8vo, pp. 360. Buffalo, N. Y. 1910.

The object of this directory is to give, as far as possible, a complete list of the museums of America, using the word in its broad sense, with information as to their purposes, character and extent of their collections, mode of support, manner of administration, staff and publications, with a brief sketch of the history of each institution. It is arranged alphabetically by states and cities, and, with the index, comprises 360 pages, 313 being devoted to the museums of the United States. The collections are listed mainly under certain specified headings; anthropology, art, botany, geology, paleontology, zoology, and the approximate number of specimens on exhibition and in the study series is stated. Great pains have been taken to have this information as exact as possible, and it will be found that in many cases there is a very considerable reduction in the size of collections from that noted in the list prepared by F. J. H. Merrill and that in a few instances there is stated to be "no museum," where one was said to exist in 1903.

The data given, checked by the character of the financial support, and a knowledge of the staff, will furnish a pretty good idea of the size and importance of the institutions noted.

The preparation of the work was authorized in 1908 at the second meeting of the Association of American Museums and the arduous duty of gathering the information and making it ready for publication was performed by Paul M. Rea, secretary of the association. The cost of issuing the work, which has been considerable, was generously borne by the Buffalo Society of Natural Sciences. It was hoped to have had the directory issued as a memorial of the Buffalo meeting of the association, but owing to inevitable delays in securing needed information it did not appear until late in 1910.

As the only directory of American museums previously issued is that prepared by F. J. H. Merrill and published in 1903, by the education department, state of New York, this volume is very welcome. We should have been glad of a brief summary, giving the number of museums in the United States, their total annual expenditure and the number of their staff, but this may well be left for some one interested in the study of statistics.

In conclusion it may be said that if, as Dr. Goode considered, the museum is the most advanced of institutions for the education of the public the United States stands well to the fore.

F. A. Lucas

Studies on the Structure and Affinities of Cretaceous Plants. By Marie C. Stopes and K. Fujii. Phil. Trans. Roy. Soc., London, Series B, Vol. 201, 1910, pp. 1–90, pls. 1–9.

A glance at the above somewhat impressive title might lead one to presume that we have to do with a paper of broad, possibly world-wide, scope, and it is not until we reach page 4 that we learn incidentally that it deals exclusively with material from Hokkaido, northern Japan. Here the authors have been exceedingly fortunate in securing nodules—presumably silicified—in which are preserved fragments of vegetation which indicate the presence of a varied and interesting flora, and suggest, in the manner of occurrence, the English Carboniferous nodules which have yielded such splendid results to Williamson, Scott and others. It is much to be regretted, however, that the present paper does not give more explicit information regarding the geological position of the material, the only data on this point consisting of the following statement: "In nearly every case there are parts of shells of Ammonites in the nodules. These have been described by Yabe, and there is no doubt, as a consequence, that the plants are of Cretaceous age." That the description of the

Ammonites by Yabe necessarily proves the Cretaceous age of the plants may, or may not, be true, but it can hardly be accepted as very definite information in itself, since Ammonites had their origin in the Triassic. Even if they are located in the Cretaceous or "Upper Cretaceous" it is not sufficiently close to permit of comparison with horizons of definite stratigraphic positions in the Cretaceous of other parts of the world. But this study avowedly was made, not from the standpoint of geological paleobotany, but from the professedly higher plane of histology, and as such it must be judged.

Those paleobotanists who, although perhaps not entirely without knowledge or appreciation of the value of structure, have made widest use of the impressions of plants, have had held before them the dictum that structure is the only road that leads to permanent accomplishment—a sort of Nirvana, as it were, which few could hope to attain. It was therefore with particular pleasure that we turned to the present paper in the hope that we should find an exposition of paleobotany founded on the solid basis of internal structure. The reviewer confesses to a feeling of disappointment.

Of the eighteen new genera and species, which range from fungi to angiosperms, it appears that hardly any is of absolutely definite position and affinity. Thus, of the fungus (*Pterosphæria*) our authors say, "the lack of characteristic spore-bearing fructifications makes its exact location impossible." Of the two forms described as ferns, the first (*Schizæopteris*) is thought to belong to the Schizæaceæ, but its affinity is uncertain, while the other (*Fasciostelopteris*) is balanced between the Cyatheaceæ, Marattiaceæ and Dicksoniaceæ, and the conclusion is reached it "may therefore for the present be provisionally included in the Dicksoniaceæ." *Niponophyllum cordaitiforme* is a leaf, and here now is the opportunity to see what can be done with internal structure as compared with an impression. After meandering through the better part of five quarto pages in seeking affinities balanced between Araucarineæ, Podocarpineæ, various genera of cycads, as well as *Cordaites,* we have the following: "Was the plant to which our leaf belonged a primitive type of cycad, or perchance a belated, small-leaved *Cordaites* surviving in this island of the orient, just as the truly archaic *Ginkgo* survived to the present geological epoch?" Since *Cordaites* had its maximum development in the Carboniferous and did not, so far as we definitely know, survive beyond the close of the Paleozoic, this discovery is of interest—if true! Their new species of *Cedroxylon* might belong, they state, either to this genus or to *Cupressinoxylon,* while the "new" coniferous genera *Yezonia* and *Cryptomeriopsis* have recently been reviewed at length by Professor Jeffrey.[1] The Anglo-Japanese authors state of their *Yezonia:* "It is impossible to find any family among gymnosperms with which we can satisfactorily include this plant," but Jeffrey shows conclusively that it is the same as *Brachyphyllum* from the Cretaceous of Staten Island, adding "if all the points of agreement between the description of the supposed new genus *Yezonia* . . . and the account of the anatomy and habit of *Brachyphyllum,* given in the present article and in the large memoir of Dr. Hollick and the present author were italicized, it would be necessary to italicize the whole description"! Their *Cryptomeriopsis* is shown by Jeffrey to be merely the old *Geinitzia* (*Sequoia*) *Reichenbachi,* that has been known from impressions since 1842.

The several angiosperms described are, if possible, in an even more unsatisfactory state as regards definiteness, and the authors acknowledge that "from the anatomy of stem and rootlets alone it is a matter of extreme difficulty and some uncertainty to determine the affinity of an angiosperm." Thus of their *Jugloxylon* they "lay no particular stress on the systematic position that the name suggests." *Populocaulis* agrees with *Populus* "more closely than with any other," while *Fagoxylon* has "general affinities with the whole Cupuliferæ," which is certainly sufficient leeway. The only angiospermic fructifi-

[1] *Annals of Botany,* Vol. 24, 1910, p. 767.

cation that came to light our authors had some difficulty in placing, finding it hard to decide whether it belonged to the dicotyledons or monocotyledons, but as a final conclusion they say: "On the whole, judging from its detailed structure and general appearance, we incline to place the flower in the Liliaceæ." Is it to be presumed that such adumbrations as the above add much to the evolutionary history of the Liliaceæ, or of the monocotyledons in general?

It is not necessary to further mention the technical portion of the paper, and it only remains to call attention to some of the nomenclatorial anomalies. All the genera and species published as new to science in the present paper were printed a year earlier in the *Geological Magazine,* London, N. S., Vol. 6, 1909, pp. 557–559, but without characterization. They are all again listed on page 1 of the paper under review, some of them incidentally mentioned at various places in the introduction, each again appearing at the head of the section of the text in which it is described, while at the end of the description there is a formal generic and specific characterization where each is called "gen. nov.," or "sp. nov." The question arises as to how these shall be cited. To give *Cryptomeriopsis* as a concrete example: Shall we quote page 1 of this paper, where it is first printed; page 3, where it is mentioned and partially described; page 52, where it stands at the head of the description; or page 57, where the genus and species are formally dedicated?

The reviewer does not wish to be understood as in any way underestimating the value of histology in establishing a firm basis on which to work out the developmental history of plants, but if the study of the internal structure of fossil plants, as contrasted with the study of plant impressions, is to be given proper weight it must be subject to the same scrutiny. If the study of the intimate anatomy of fossil plants leads only to indefiniteness and inconclusion, it is not entitled to greater weight than attaches to the study of the impressions of plants.

F. H. Knowlton

SOME RECENT ADVANCES IN FLUORESCENCE AND PHOSPHORESCENCE[1]

After an opening period of great activity, which began with Becquerel, Herschel and Stokes and included the important work of Lommel, Wiedemann and Schmidt and of numerous other physicists, there was a long time of comparative quiescence during which *luminescence,* to use the word proposed by E. Wiedemann, was a neglected branch of optics. Quite recently there has been renewed activity in this field and it is of some aspects of this newer work that I shall try to give a brief account. No approach to a complete summary can be made in a single paper and I shall deal chiefly with certain investigations which are particularly suggestive of the beginnings of correlation in this involved and obscure portion of the science of radiation.

The Relations of Phosphorescence to Fluorescence.—The common view that phosphorescence is simply what remains of fluorescence after the cessation of excitation would seem to need essential modification according to the latest paper of Lenard,[2] who, after extending his observations to some fifty phosphorescent compounds, made by the addition of a trace of some metallic salt to a sulphide of strontium, barium or calcium and certain heat treatment with a flux, considers that it is necessary to distinguish two phenomena, the one temporary, which ceases almost instantly after the end of excitation (*Momentan-process*), and the phenomenon of long-time phosphorescence (*Dauer-process*). The distinction is three fold: The momentary process may be produced independently of the other (1) by very brief excitation; (2) it may be excited by the use of portions of the ultra-violet spectrum which are incapable of producing long time phosphorescence or (3) at temperatures above or below the range within which long-time phospho-

[1] Abstract of a paper presented before Section B at the Minneapolis meeting of the American Association for the Advancement of Science.

[2] Lenard, *Annalen der Physik* (4), Vol. XXXI., p. 641, 1910.

rescence can be excited. Lenard regards the phosphorescence spectrum as consisting of one or more well-separated, broad and continuous bands usually lying within the visible spectrum. Detailed study of these bands with the spectrophotometer,[3] however, shows that they are really of a very complex structure and consist of overlapping components which can not be separated altogether for any given temperature or mode of excitation, but which are so differently affected when the wave-length of the exciting light is varied or when excitation occurs at different temperatures, as to indicate that they are not due to the luminescence of one and the same molecule or aggregate. It is probably on account of this complexity of the phenomena that Lenard has reached his view of the case. Certainly the evidence of recent work by Pierce,[4] Waggoner[5] and Zeller[6] goes to show that whatever may be true of phosphorescent sulphides prepared by the method of Lenard and Klatt, the relation between phosphorescence and fluorescence is in many other instances the intimate one that has usually been assumed to exist.

Fluorescence in the Ultra-Violet and the Infra-Red.—Stark and Meyer[7] have in a recent paper shown the existence of numerous fluorescence bands lying in the ultra-violet spectrum. In the case of the benzol derivatives with which their measurements have to do fluorescence depends for its position upon the complexity of the molecule and it is found that, as a rule, the heavier aggregations have bands in the longer wave-lengths.

Steubing[8] finds spectrum lying at still shorter wave-lengths (.1884μ) which he ascribes to the fluorescence of oxygen. This spectrum, like the corresponding spectra for vapors of gases having fluorescence in the visible spectrum, as described by Wood,[9] consists of a group of bands regularly but not uniformly spaced. As may be seen in Fig. 1 the distance between the bands increases gradually with increasing wave-length. Beginning at that end of the group which lies furthest in the ultra-violet, the intensity of the individual bands rises very rapidly to a well-marked maximum and falls off more slowly as the wave-length increases. An inspection of the remarkable photographs made by Wood of the fluorescence of sodium and other vapors leads one to believe that were measurements made of those spectra a similar distribution of intensities would be found to exist.

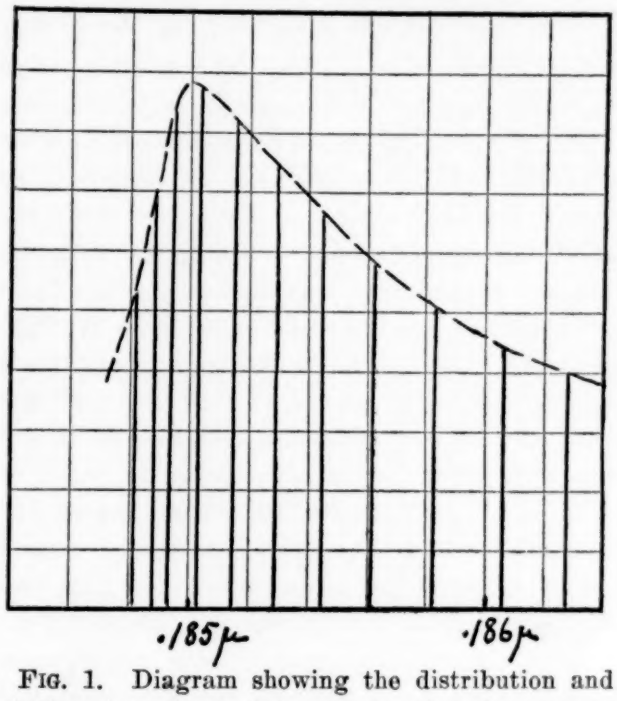

FIG. 1. Diagram showing the distribution and relative intensity of bands in the fluorescence spectrum of oxygen (Steubing).

Pauli[10] has recently subjected the preparations of Lenard and Klatt to systematic study, particularly with the view of corroborating Lenard's hypothesis that the active metallic atom embedded in the sulphide is to be re-

[3] Nichols and Merritt, *Physical Review*, Vol. XXXII., p. 38.

[4] Pierce, C. A., *Physical Review*, Vol. XXVI., pp. 312 and 454; XXX., p. 663.

[5] Waggoner, C. W., *Physical Review*, Vol. XXX., p. 663.

[6] Zeller, C. A., *Physical Review*, Vol. XXXI., p. 367.

[7] Stark and Meyer, *Physikalische Zeitschrift*, Vol. 8, p. 250.

[8] Steubing, *Annalen der Physik* (4), Vol. XXXIII., p. 553, 1910.

[9] Wood, *Philosophical Magazine* (6), Vol. X., p. 513; Vol. XV., p. 581; Vol. XVI., p. 184.

[10] Pauli, *Physikalische Zeitschrift*, Vol. XI., p. 991.

garded as an electric oscillator, the period of vibration of which depends upon inductance and capacity. By modifying the dielectric constant of the solvent it was found that the position of the fluorescence band could be altered at will and Pauli succeeded in producing preparations having bands in the ultra-violet only and in other cases only in the infra-red.

The Complexity of the Fluorescence Spectra of Solids.—The complexity of fluorescence spectra which was first so strikingly exhibited in Wood's studies of sodium vapor is by no means confined to gases. Not only do we have solids whose spectra are made up of overlapping bands due to the presence of several fluorescing constituents, as in the case of the sulphides of Lenard and Klatt, but there are also substances of definite chemical composition, notably the uranyl salts, the fluorescence spectra of which consist of a group of several bands arranged in a manner which suggests the banded spectra of gases. E. Becquerel[11] in 1872 studied these fluorescence bands and discussed their relations to the corresponding absorption spectra. The subject has since received the attention of numerous investigators; the most recent contribution being that of Jones and Strong.[12] Henri and Jean Becquerel,[13] working at Leiden with Kamerlingh Onnes, have studied the fluorescence spectra of uranyl salts; photographing the same at 288° of the absolute scale, 80° (liquid air), 20° (liquid hydrogen) and 14° (solid hydrogen). Under these conditions the already unusually narrow bands are reduced to mere lines in the spectrum and each band is found to consist of a group of such lines.

The relation of the narrow fluorescence bands of the uranyl salts to the broad bands in the fluorescence spectra of other solids and liquids is not at first sight obvious. They appear to be intermediate between the broad bands usual to solids, of which sometimes only one exists, and the complicated groups of lines observed in the case of vapors. Some recent studies of the uranyl bands appear, however, to throw some light on this relationship.[14] Hitherto attention has chiefly been directed to the location of the bands in the spectrum. When, however, we measure the relative intensities of such a group of bands we find them to be related in a very interesting manner. The curve showing the relation between wave-length and intensity of the seven strongest bands in the fluorescence spectrum of such a salt has a form which is essentially identical with that of the typical curve for the distribution of energy in the broad single bands of ordinary fluorescence spectra. The shape is the same for the various uranyl salts; being shifted slightly in wave-length with the chemical composition or with the presence or absence of water of crystallization.

Fig. 2 will serve to indicate the characteristic form of these curves and the shift

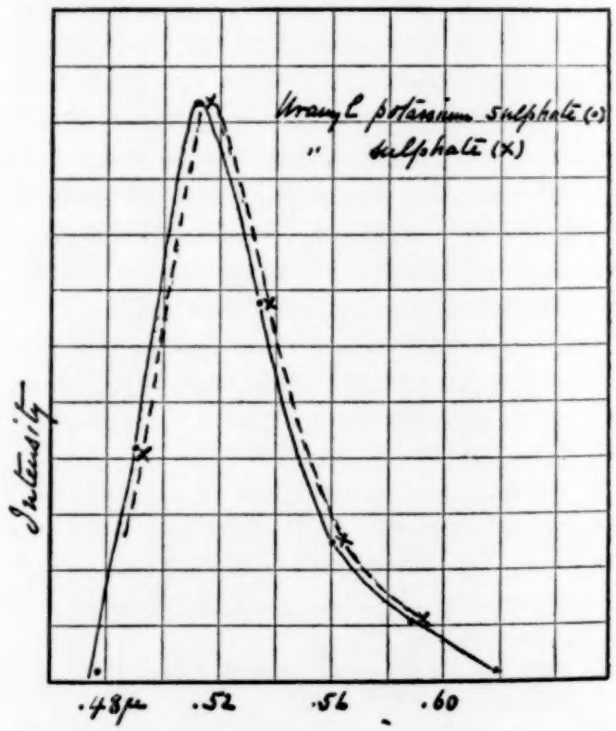

Fig. 2. Relative intensities of the seven principal bands in the spectra of two uranyl salts.

[11] E. Becquerel, *Mémoires de l'Académie des Sciences*, XL., 1872.

[12] Jones and Strong, *American Chemical Journal*, XLIII., p. 37.

[13] H. and J. Becquerel and Onnes, "Leiden Communications," No. 110.

[14] Nichols and Merritt, "On the Fluorescence Spectra of the Uranyl Salts and on the Structure of Fluorescence Bands in General." A paper presented at the Minneapolis meeting of the American Physical Society, December 28, 1910.

due to change in chemical composition. The examples selected are uranyl sulphate ($UO_2SO_4 \cdot 3H_2O$) and uranyl potassium sulphate ($UO_2SO_4 \cdot K_2SO_4 \cdot 2H_2O$).

That this relation is not an accidental one, but that these various bands are probably due to the oscillations of one and the same complex mechanism may be almost conclusively established by observing the spectrum under various conditions of excitation and of temperature. When we subject accidental combinations due to different substances in a fluorescing mixture to such changes the independence of the various components is readily shown, but in the case of the uranyl bands when excited by the monochromatic light of various lines of the mercury arc from .4538μ to .2536μ it is found that the relation between the intensities of individual bands remains very nearly the same. When the substance is gradually cooled to the temperature of liquid air and observations are made at intermediate temperatures, it is found that all of the bands shift towards the violet and that their gradual movement as the temperature changes is of the same character for all. The relation of intensities in this case does not remain the same, but it is significant that the changes are such as to produce a modification in the curve of relative intensities precisely similar to that which is known to occur in the case of the ordinary broad continuous fluorescence bands when the excited substance is cooled. It would therefore appear that we have in the case of the fluorescence of the uranyl compounds a single fluorescence band of the usual type but broken up into several easily separable components. It is easy to imagine that a continuance of the change which occurs in the fluorescence of these substances as the temperature rises from that of liquid air to $+20°$ C. would result in the merging of these components into a continuous band in which they could no longer be distinguished from one another.

In the case of some of the uranyl salts, indeed, the overlapping of the bands is considerable under ordinary conditions, as may be seen in Fig. 3, which is from measurements of the three strongest bands of uranyl nitrate at 20° C.

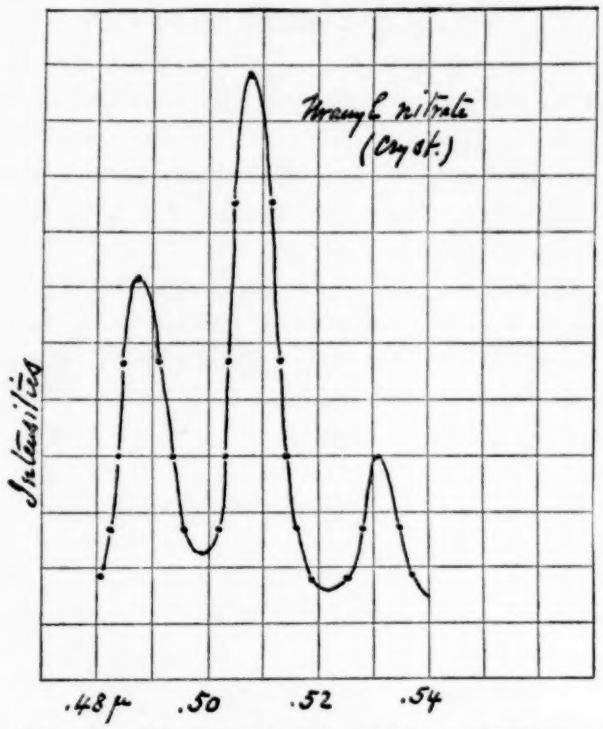

FIG. 3. Diagram showing the overlapping of the three principal bands in the fluorescence spectrum of uranyl sulphate.

The relation may be carried still further when we consider that the broad continuous bands of fluorescent substances are always associated with a broad absorption band usually overlapping the fluorescence band on the side toward the violet and that the absorption spectrum of the uranyl salts consists of a series of bands precisely similar as regards their arrangement and number to the bands of the fluorescence spectrum. This group of bands according to E. Becquerel is to be regarded as a continuation of the series of fluorescence bands. It has been shown by H. and J. Becquerel and Onnes[15] to overlap the group of fluorescence bands. According to their photographs the bands nearest the red in the absorption group when observed at the temperature of liquid air are nearly if not quite coincident with the last ones of the fluorescence group towards the violet.

As in the case of the fluorescence bands of the uranyl salts, the absorption bands increase

[15] Becquerel and Onnes, *l. c.*

in intensity as we pass from either end towards the middle of the group, and we may depict the relation of the two groups by drawing the enveloping curve for the region of absorption and for that of fluorescence and showing the extent to which they overlap, as in Fig. 4. While detailed quantitative studies of the absorption bands have not yet been made, the preliminary observations indicate that the enveloping curve is an "image" of that of the group of fluorescence bands, just as the broad absorption band of resorufin and other fluorescent substances has already been shown[16] to be the overlapping image of the corresponding fluorescence band.

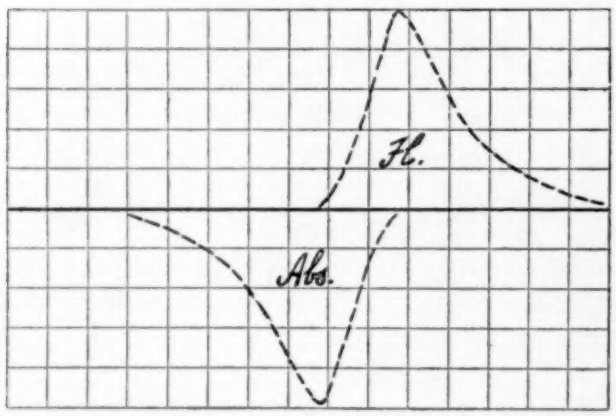

FIG. 4. Diagram showing the overlapping of fluorescence and absorption in the case of a uranyl salt.

Not only is the envelope of the fluorescence group of the same type as the curve of distribution of energy in ordinary fluorescence bands, but each component, as has been shown by spectrophotometric measurements, has a similar distribution of energy. Moreover, both curves have the same characteristics, although with very different scales of wave-length, as the energy curve of the temperature radiation of a black body. That the relation between the luminescence of solids and liquids and that of vapors is an intimate one is strongly suggested by the comparison of the diagram from Steubing's measurements of the fluorescence of oxygen (Fig. 1) with the curves for the uranyl salts just described, and this suggestion is strengthened by the inspection of Wood's curves for the fluorescence of sodium vapor. Moreover, the family resemblance of all these related cases of banded fluorescence spectra to the banded spectra of gases as we find them described in the papers of Deslandres and of Kayser and Runge is unmistakable. In view of these numerous indications of a common property may we not anticipate the attainment of some broader generalization concerning the various types of radiation than has hitherto been made?

E. L. NICHOLS

[16] Nichols and Merritt, *Physical Review*, Vol. XXXI., p. 376.

NOTES ON THE PRELIMINARY REPORT OF THE COMMITTEE ON THE TEACHING OF MATHEMATICS TO STUDENTS OF ENGINEERING

AT the meeting of the Society for the Promotion of Engineering Education held at Madison, Wis., in June, 1910, the members present were handed sets of galley proofs of the Preliminary Report of the Committee on the Teaching of Mathematics to Students of Engineering, which committee was appointed at a joint meeting of the American Mathematical Society and Sections A and D of the American Association for the Advancement of Science in December, 1907. The committee consists of twenty members, ten of them being professors of mathematics, three presidents of technical institutions and seven professors of engineering and consulting engineers.

The report being only a preliminary one, it is subject to amendment before being presented as a final report, and no doubt the members of the committee will be glad to receive any suggestions which will tend to make the report more useful and more acceptable to engineering teachers. The writer acknowledges the great value of the report as a whole, but he has some criticisms to offer on one portion of it, viz., elementary dynamics, which he hopes will be carefully considered by the members of the committee and by others interested, who may be led by it to offer the committee additional suggestions.

In the preface to the report it is said:

> The defects in the mathematical training of the student of engineering appear to be largely in knowledge and grasp of fundamental principles,

and the constant effort of the teacher should be to ground the student thoroughly in these fundamentals, which are too often lost sight of in a mass of details.

The defects mentioned are universally admitted and complained of, and they are perhaps more apparent in the subject of elementary dynamics than in any branch of pure mathematics, but the writer is of the opinion that they are due rather to the text-books than to the teachers. As the committee says: "What is most needed at the present time is a series of synoptical text-books which shall present in compact form (1) the fundamental principles of the science, and (2) a classified and graded collection of problems."

The writer heartily commends the two following sentences in the report:

> The poundal is never used in practise, and no instruments are on the market which give readings in poundals; it should be dropped from the text-books. The so-called "engineers' units of mass," namely, the G-kilogram, or "metric slugg," and the g-pound, or "slugg," are never used in practise, and no set of weights is on the market giving readings in terms of these units; they should be dropped from the text-books.

The chief trouble with the text-books is due to the fact that some early writer, in his attempt to overcome what he conceived to be a difficulty in teaching the subjects of weight and mass, invented the "poundal," and others invented the "engineers' unit of mass," "gee-pound" or "slugg" (32.2 pounds of matter), to overcome the imaginary difficulty, and other text-book writers blindly followed them. These devices did not overcome the difficulty, but on the contrary only created confusion, and students had to spend weary hours on these worse than useless units, which afterwards, when they became engineers, they had to unlearn.

The idea of the "poundal" is probably a development of the "C.G.S." system, in which 1 dyne (force) acting on 1 gram (matter) free to move, for 1 second, gives it a velocity of 1 centimeter per second. In English units, if 1 pound force acts for one second on 1 pound of matter, the velocity at the end of the time is 32.2 feet per second. If the English system only had either a unit of force = 1/32.2 pound, or a unit of quantity of matter = 32.2 pounds, then the figure 32.2 in the equation of the relation of force to acquired velocity would disappear, and the equation would look simpler; so the two new units, poundal and gee-pound, were invented, to the confusion of the subject, and they now have to be expunged from the language.

Merely getting rid of the poundal and the gee-pound, however, does not get rid of the whole trouble arising from the use of the same unit, pound, to express both a force and a quantity of matter. The committee (or perhaps only one or two members of it, to whom were assigned the subject of dynamics) have wrestled with the problem, but in the writer's opinion they have failed to find the best solution of it.

In order to make this criticism as clear as possible, the following extracts are first made from the committee's report, and comments on the several paragraphs follow.

Extracts from the Report

(*a*) The most important mechanical quantities for engineering purposes are length, time, angle and force. Derived from these are: area, volume, pressure, linear velocity, etc.

(*b*) Less important for the engineer, but of great importance in general scientific work, is the quantity called "mass" (galley 39).

(*c*) The units of mass are of little importance to the engineer, since the quantity that enters into the equations of engineering is not the mass of the body, in units of mass, but its normal weight, in units of force.

(*d*) The mass of a body may be thought of, roughly, as the amount of matter in a body (galley 40).

(*e*) The ratio W/g for a given body is constant in all localities. This quantity, or a quantity proportional to this ratio, is called the *mass, m,* of the body (galley 35).

(*f*) The weight, W, of a body, at a given place, is the force that causes it to fall when unsupported (galley 34).

(*g*) If the mass of a body is one pound

(mass) then its normal weight is one pound (force) (galley 35).

(*h*) The normal weight, W_o, of a body is its weight in vacuo, at sea level in latitude 45°.

(*i*) A "set of standard weights" is a set of metal pieces each of which is marked with its normal weight.

(*j*) The process of weighing a body on an equal arm balance, against a set of standard weights, gives the normal weight of the body.

(*k*) The process of weighing a body on a *spring balance,* on the other hand, gives the *local weight* of the body.

(*l*) To graduate the scale of a spring balance find the local weight of a set of standard weights as just explained (by computation from the value of g at the locality in question) and then suspend the pieces successively on the spring, and mark on the scale the deflection caused by the local weight of each piece (galley 34).

(*m*) Force may be thought of, roughly, as a push or a pull.

(*n*) $F/W = A/g$ is taken as the fundamental equation.

(*o*) If in the fundamental equation $F/W = A/g$ we substitute the equation for mass, $m = c(W/g)$, where c is the numerical factor depending on the choice of units, we have $cF = mA$. Any system of units which makes $c = 1$ in this equation is called an absolute system of units.

(*p*) The equation $F = mA$ will give incorrect results if the forces and masses are given in any but absolute units. In particular it should never be used in the ordinary problems of engineering.

(*q*) On account of the special character of this equation $F = mA$ it is unfortunate that it should be so often taken as the fundamental equation of dynamics instead of the general equation $F/W = A/g$ from which it is derived (galley 41).

Comments on the above Extracts

(*a*) For "length, time, angle and force," we would better read "space, time, matter and force." Mechanics is the science of the action of force upon matter. Matter is that upon which force acts, and it is just as important as force in most engineering problems. Matter occupies space, therefore space is one of the four elementary concepts of mechanics. Length is merely the linear measurement of space in one direction, and therefore it should be placed in the list of derived quantities, with area and volume. Angle should also be placed in the list of derived quantities; it is the difference in direction of two lines that meet in a point, or the difference in position of a line that is rotated a certain distance about one of its ends.

(*b, c*) If "the quantity called mass" is the quantity of matter in a body, then this statement is incorrect. The quantity of matter in a body is of the utmost importance to the engineer, independent of the force of gravity acting upon it, if the body is to be moved horizontally, or rotated, or accelerated, or if he or his client has to pay for it.

(*d, e*) Here are two definitions of "mass" which are inconsistent. If mass is the quantity of matter, why should it be "thought of, roughly"? Why is it not defined with precision as the quantity of matter as determined accurately by weighing it on an even balance scale and compared with the standard pound (or kilogram)?

The second definition is the ratio W/g, or a quantity proportional to this ratio.

The fact is that the word "mass," as applied to matter, is used in three different senses:

1. As synonymous with "portion," "piece" or "lump" of matter, as in the expression "this mass weighs ten pounds," the words "weighs ten pounds" referring to the quantity of matter as determined by weighing.

2. As synonymous with the word "weight" (quantity of matter), as the word weight is universally used in ordinary language, and nine times out of ten by the engineer, who rarely uses the word "mass" in this sense. Example: "This lump has a mass of ten pounds."

3. As synonymous with the ratio W/g, where either W is the weight (quantity of matter) and g is 32.174, the acceleration due

to gravity at the sea level at latitude 45°, or W is the force with which gravity attracts the body at any given place and g is the acceleration due to gravity at that place. The quantity or ratio W/g is constant in either case. In this the mass of the ten-pound lump is 10/32.174, and since it is a ratio it has no unit. The statement that "the engineers' unit of mass is 32.2 pounds," found in some books on physics, is incorrect. The engineer has no such unit.

Giving the name "mass" to the ratio W/g was perhaps unfortunate, but it can not now be helped, since it is universally used in this sense in the engineering text-books of the past sixty years or more. It is a handy term, and the use of the single letter M instead of the fraction W/g often simplifies calculations. It is hard enough to get rid of a bad term, for example, "poundal," which has been in the high-school books on physics for the past thirty years in spite of the numerous attacks upon it. It is not likely that we can get rid of the term mass, M, in the sense of W/g unless some one invents another and a better name for it.

Of course confusion results from the three different meanings given to the same word "mass," but the confusion arises chiefly from its use in the second sense given above, as synonymous with weight (quantity of matter). It is so used in all the books on physics, but as already stated, is rarely so used by engineers. It would tend to diminish the confusion if the books on physics mentioned that in engineering "mass" means the ratio W/g, and not the quantity of matter in pounds, thus preparing students for what they will afterwards learn in their engineering studies.

(f) "The weight, W, of a body, at a given place, is the force that causes it to fall if unsupported."

The word "weight" is used in two senses: (1) in the sense given in the above definition, which is that of the text-books on physics, and (2) in the sense of quantity of matter as determined by the common method of weighing it. In this sense it is used universally in ordinary literature and in commercial transactions, and nine times out of ten by engineers, in all calculations in which quantity of matter is involved.

In this sense W is a constant quantity; in the first sense it is inconstant, varying with the latitude and with the elevation above the sea level.

In the second sense, quantity of matter, the word weight was used long before Newton's time. It is thus used in the clause of the constitution of the United States that authorizes congress to fix the standard of weights and measures, in acts of congress establishing the Bureau of Weights and Measures, and in acts of the British parliament. It is thus used in the King James version of the English Bible: "And they shall eat bread by weight" (Ezek. 4: 16). It is not conceivable that this meaning of the word "weight" can ever go out of use. It is in the language of the people and it is there to stay.

The beginning of confusion in the minds of students as to the meaning of the words "weight" and "mass" results from the fact that the high-school text-books use the word mass for what is commonly called weight, and attempt to restrict the word weight to mean only the force with which a body is attracted by gravity at a given place.

(g, h) "If the mass of a body is one pound (mass) then its normal weight is one pound (force)."

By mass we here understand quantity of matter, and not the ratio W/g given in definition (e).

The "normal weight" (this appears to be a new and useless term, and therefore undesirable) is the force with which a body is attracted to the earth by gravity at latitude 45°.

If the sentence (g) were made to read: "If the weight of a body is one pound, then the force with which gravity attracts it at the sea level in latitude 45° is one pound," it would be strictly accurate, in harmony with the every-day use of the language, and would avoid the confusion arising from the use of the word "mass." The meaning of the word "weight" in this sentence is not ambiguous

or doubtful. It means both that the quantity of matter will balance the standard pound on an equal arm balance, and that the force which gravity exerts on it at latitude 45° is one pound, as indicated by a properly graduated spring balance.

(*i*, *j*) If for the words "normal weight" in these two sentences we use simply the word weight, it will express the idea accurately, whether the word means quantity of matter or the force with which gravity would act on the body at latitude 45°. The two meanings are synonymous and the two quantities identical. The measure of the quantity of matter in a body is the measure of the force with which gravity attracts it at latitude 45°.

(*k*) The process of weighing a body on a spring balance, on the other hand, gives the "local weight" of a body. The term "local weight" also appears to be new, but as it strictly expresses the idea of the attraction of gravitation on a body at a given locality, and there is no other short term that so clearly expresses it, it may be considered unobjectionable. The words "gravity of a body" might properly be used to express the idea, if text-book writers would agree to it, for its value would vary in the same proportion as the earth's gravitational force varies, with the locality.

The sentence (*k*), however, is true only if the spring balance has been graduated with standard weights at latitude 45°. If graduated with standard weights at the locality (other than lat. 45°) where the weighing is done, it will give the "normal weight," or quantity of matter, just as an even balance would do.

(*l*) This sentence is not clear. A spring balance graduated, say, at latitude 30°, by hanging on it successively the standard weights, 1, 2, 3, 4, etc., pounds, and marking the deflection shown by each, will show at latitude 30° the weight (quantity of matter) of bodies weighed on it, but if it is desired that the balance should indicate "local weight," then the standard weights hung on it should be increased in the proportion that the attraction of gravitation is less at latitude 30° than at latitude 45°, or in the ratio $32.174 \div 32.131$, or $1/1.0013$. If 1.0013 pounds is hung on the scale it will indicate 1 pound, and 1 pound hung on it will indicate 0.9987 pound, the "local weight" of 1 pound of matter at latitude 30°. Spring balances, however, are never used for weighing as accurately as 1.3 parts in 1,000, since for such weighing a microscope would be needed to read the deflections. "Local weight" is rarely needed in engineering problems, and if it should be needed it is determined not by weighing on a spring balance but by multiplying the weight (quantity of matter) by the ratio of the value of g at the location to 32.174.

(*m*) "Force may be thought of, roughly, as anything of the nature of a push or a pull." Why "roughly"? The definition of force as a push or a pull is as precise as language can make it.

(*n*) "$F/W = A/g$ is taken as the fundamental equation." This is only one form of the fundamental equation. The fundamental fact in dynamics is that if a force F is exerted constantly for a time T upon a body free to move, whose weight is W, giving it a velocity V (starting from rest when $V = 0$) at the end of the time T, then the following equation is true (in the foot-pound-second system of units):

$$FT = (W/g)V,$$

or, if $A = V/T$ then $Fg = WA$, from which the equation $F/W = A/g$ is derived; also if $M = W/g$, then $FT = MV$ and $F = MA$.

(*o*) "If in the fundamental equation $F/W = A/g$ we substitute the expression for mass, $m = c(W/g)$, where c is the numerical factor depending on the choice of units, we have $cF = mA$. Any system of units which make $c = 1$ in this equation is called an absolute system of units."

The value of c in the foot-pound-second system is given as 32.174, and in the dyne-gramme-second system as 1. In the foot-pound system $m = 32.174\,W/g$.

This is out of harmony with the engineering text-books and with engineering literature

generally, which make $M = W/g$. If students are taught in elementary mechanics that $m = 32.174 W/g$ and in engineering that $M = W/g$, the resulting confusion will be as great as that caused by the poundal and the gee-pound.

(*p*) "The equation $F = mA$ will give incorrect results if the forces and masses are given in any but absolute units. In particular it should never be used in the ordinary problems of engineering."

The reasoning that leads up to this conclusion would also condemn the use of the time-honored formulæ $FT = MV$ and $FS = 1/2MV^2$.

The equation $F = MA$ is given in all engineering text-books that deal with problems in dynamics, and it has been used from time immemorial with English units and with perfect accuracy.

(*q*) "On account of the special character of this equation, $F = MA$, it is unfortunate that it should be so often taken as the fundamental equation of dynamics, instead of the general equation $F/W = A/g$ from which it is derived."

As commonly used by engineers the equation $F = MA$ has no more a special character than the equations $FT = MV$ and $FS = 1/2MV^2$. It is just as fundamental as $F/W = A/g$, which as well as $F = MA$ may be derived from $FT = MV$. If in the last equation we take $V/T = A$, then $F = MA$; and if $M = W/g$, then $F/W = A/g$.

Whether a certain equation should or should not be used in engineering depends, (1) on its logical correctness, (2) upon its usefulness. The three equations $F = MA$, $FT = MV$ and $FS = 1/2MV^2$, are all logically correct, equally in the so-called "absolute" (C.G.S.) system, the pound-foot system, and the kilogram-centimeter system, provided that in the C.G.S. system the unit of quantity of matter is the gram and the unit of force is the dyne, or 1/981 of the force with which gravity attracts a gram of matter at latitude 45°; that in the pound-foot system $M = W/32.2$ and that in the kilogram-centimeter system $M = W/981$, W being the weight of the body in pounds (or kilograms) and the definition of weight being the quantity of matter in a body, or the force with which gravity attracts it at latitude 45°. As to the usefulness of the equations, this has never heretofore been doubted. They have filled the engineer's need for a set of handy formulæ for accelerated motion, and they are easily understood by the student.

More than ten years ago a high-school student in despair over his problems in dynamics, on account of the obscurity of his text-book and of the teacher's explanations, appealed to the writer for assistance. He was told to forget the formulæ of the text-book, with its poundals and units of mass and to memorize the following: $V = \sqrt{2gh}$, $S = 1/2VT$, $FT = MV$, $F = MA$, $FS = 1/2MV^2$ and $M = W/g$, F being force in pounds, M nothing else than $W/g = W/32.2$, or $W/32.174$ (if great precision is needed) (no "concept of mass" needed) and W weight in pounds (quantity of matter as weighed on a platform scale). With these equations the student soon solved every problem in the book that referred to bodies uniformly accelerated. Many times since the writer has had occasion to give the same advice, and always with the same result.

Here is a simple problem in acceleration, with its solution by the engineer's method and by the method of the committee's report.

What is the draw-bar pull required to accelerate a railroad car whose weight is 100,000 pounds, on a level track, in latitude 30°, at the rate of 1 foot per second per second, friction neglected? The engineer's solution:

$F = MA$, $M = W/g$, $A = (V_1 - V_0) \div T$

$F = 100{,}000 \div 32.2 \times 1/1 = 3{,}105.6$ pounds.

The mathematician's solution: First look up the value of g for latitude 30°, $= 32.131$. In latitude 45° $g = 32.174$. Weight is the force with which gravity attracts a body at a given place. The unit of force (pound) is the force with which gravity attracts the standard pound at latitude 45°, where $g = 32.174$. A weight of 100,000 pounds at latitude 30° is therefore a force of $100{,}000 \times 32.131/32.174$ pounds, $= W$. "The formula $F = MA$ should never be used in the ordinary problems of en-

gineering." Using the formula $F/W = A/g$ we have $F = AW/g$. Since g is to be taken for latitude 30° its value is 32.131. We then have $F = 1/1 \times 100{,}000 \times 32.131/32.174 \times 1/32.131 = 3{,}108.1$ pounds.

If the engineer had used the more precise value of g at latitude 45° he would have obtained the same result as the mathematician. He would not consider that the value of g at latitude 30° entered into the problem at all. In the mathematician's solution it enters twice, in numerator and denominator, and therefore cancels out.

The only cases in which the engineer ever needs to consider the value of g at latitudes other than 45° are those of precise calculations in which the force of gravity at a particular place enters into the problem, as in the case of the velocity of falling bodies, the power of falling water, the value of the mechanical equivalent of heat, etc. Thus the mechanical equivalent of heat is 777.52 foot pounds, or the work of lifting 1 pound 777.52 feet high, at latitude 45°. The figure obtained by experiments made in raising weights at a lower latitude would be greater in the proportion that the attraction of gravity is less. Steam at a temperature of 327.8° F. has a pressure of 100 pounds per square inch above vacuum if the pressure is measured by its lifting a weight (piece of metal) at latitude 45°. It would raise a heavier weight, in the ratio 32.174/32.131, at latitude 30°, and a lever safety valve would have to be loaded with a larger weight at latitude 30° than at latitude 45° to resist the pressure. A bar of metal tested on a lever testing machine at latitude 45° and showing an ultimate resistance of 32,131 pounds would show 32,174 pounds if tested at latitude 30°, since at latitude 30° the poise on the lever would be attracted less by gravity than at latitude 45°, and it would have to be moved farther out on the scale beam to balance the ultimate load applied to the test piece.

Note on "The Concept of Mass" (Galley 35).

It is not clear just what the report means by the word "mass." It is defined in one paragraph as "the ratio W/g, or a quantity proportional to this ratio, $m = c(W/g)$, W here being a force and not a quantity of matter," but a little later appears the expression "the mass of the body measured in units of mass," indicating that by mass is meant quantity of matter.

A great deal of mental energy has been wasted by teachers and text-book writers in trying to give high school and college students a "concept of mass," and more trouble is yet in store for teachers and students if future text-books adopt the language of this report concerning the "concept."

A boy before he goes to the high school has a perfectly clear idea of matter and of weight. He knows that matter is weighed by the grocer on even-arm balances and platform scales, and he has seen meat weighed on spring balances. He knows that in order to answer the question "How much sugar is in that package?" the weight of the package is obtained by weighing it with a balance, using pieces of metal called weights, or by putting it on a spring balance and noting the indication. He knows that the weight of a pound of lead is 1 pound, whether it is weighed in London or in Panama, and that it is bought and sold as a pound everywhere that English weights are used. He has never heard the word "mass" except in its common meaning, of something like "bulk," or as a general term of indefinite quantity, as in the expression in the preface of the report, "lost sight of in a mass of details." When he begins to study physics, however, he has to learn that what he thinks he knows about weight is all wrong, that the weight of a thing is not constant, but variable, varying with the latitude and elevation above sea level; that it is not the measure of quantity of matter, but only of the force with which the earth's gravity attracts matter; that the word "mass" should be used where he formerly used "weight"; and that he must get a "concept" of mass different from the concept of weight. Later he learns that mass is also $c(W/g)$, the ratio of the force with which gravity attracts matter at a given place to the acceleration due to gravity at that place, multiplied by a coefficient, c, which has

different values according to which system of units is used, there being six systems, kilogram-centimeter, pound-foot, dyne-centimeter, poundal-foot, G_0-kilogram-centimeter and g_0-pound-foot, that in the first system the value of c is 980.665; in the second, 32.174; and in the other four systems 1, but that the last three are only in the text-books (and students must study them and pass examinations on them) and are never used in practise. He is also told that the engineer has a different unit of mass from the physicist, 32.2 pounds, which is not true.

When the student gets into practical engineering studies he is told to forget all he learned about the "concept of mass" and that he need think of the word "mass" only as a short term to use instead of the ratio W/g, $=M$, without any coefficient, c, that weight, W, has the same meaning that it has in commerce, quantity of matter, and that g in that ratio is always the constant, 32.2, or, to be more precise, 32.174. What then is the use of confusing the young student with so many notions of the "concept of mass" when he has to unlearn them later?

The Definitions that should be in the Text-books

Criticisms of the definitions of mechanical units given in the report of the committee will fail of their proper effect unless other definitions are offered which the committee may possibly consider when the report is revised for final publication. The following definitions are offered for such consideration as they may deserve.

Weight, W. (1) Quantity of matter in a body, as weighed anywhere on an even balance scale with standard weights. (2) The force with which the earth's gravitation attracts a body at the sea level in latitude 45° (or at any place where the acceleration due to gravity is 32.174 feet per second per second).

Unit of Weight. The pound, the quantity of matter in the standard piece of metal preserved in the bureau of standards in London.

Force. That which causes or tends to cause or to change motion. A push or a pull.

The Unit of Force. The pound; the attraction of the earth's gravitation on a pound of matter at the sea level at latitude 45°.

The weight of a body, W, is both the number of pounds of matter it contains and the number of pounds of force with which it is attracted to the earth at latitude 45°. The two numbers are exactly the same and therefore it is unimportant which definition is used in connection with the solving of problems.

Local weight, W_1, the force with which the earth's gravity attracts a body at any given place, measured in units of force. It may be determined by weighing it accurately on a spring balance which has been graduated at latitude 45°, with standard weights, or, more easily, by computation, multiplying the weight, W, by the ratio of the value of g at the given locality to 32.174. W_1 varies with the location of a body. The difference between the weight of a body and the "local weight" at latitude 30° is $(32.174/32.131) - 1$, or 0.0013 of a pound, for each pound. The difference, 13 pounds in 10,000, is so small that it need not be taken into account in any ordinary engineering calculation; in fact, the "local weight" is practically never used in engineering problems. When it is needed it is found by computation from the value of g at the given locality.

Mass, M. (1) W/g, the ratio of the quantity of matter in a body (or of the attraction of the earth's gravity upon it at latitude 45°) to the acceleration due to gravity at latitude 45° (32.174 feet per second per second). This is the meaning of the word "mass" when it is used in engineering problems. (2) The quantity of matter in a body, identical with W (1) above, what is called weight ordinarily in commerce and in literature. This is the definition used in many text-books on physics, in which "weight" is restricted to mean what is defined as "local weight" above.

In answer to an objection that may be raised to the double definition of W, (1) and (2), that the same word, in science, ought not to be used to express two ideas that are so dif-

ferent as matter and force, it may be said that the two are in reality one definition. Suppose that a piece of metal, the standard pound, is hung on a spring balance. The position of the pointer on the scale is then marked 1 pound. A second piece of metal is substituted for the first, and if it brings the pointer to the same mark we say its weight is 1 pound. The 1-pound mark indicates two things at the same time, viz., that the quantity of matter in the second piece of metal is 1 pound, and that the force with which it is attracted by gravity is 1 pound. The word weight is thus logically and accurately defined by what may appear to be a double definition. No useful purpose is gained by applying another word "mass" to mean one part of this definition; on the contrary, the use of the word "mass" in this sense is the chief cause of all the confusion to which students are subjected in their study of dynamics.

William Kent

SPECIAL ARTICLES

A STRENGTH AND ENDURANCE TEST

Some time ago one of the newspapers in Kankakee, Ill., arranged a strength and endurance test in which the contestants were to walk 10 miles, each carrying on his back a sack of sand weighing 100 pounds. The course was laid out over the city streets around several blocks, and to complete the test a contestant must cover it 12 times. According to the estimate of the county surveyor, the course was 4,320 feet (1,316.7 meters) in length, and the 12 laps fixed upon for the contest would, therefore, give a total of 9 miles and 4,320 feet (15.8 kilometers), or approximately 9¾ miles, instead of the estimated 10 miles. The contest required about 4 hours, beginning about two o'clock in the afternoon and closing at dark, which would be about six o'clock on a November day. Prizes were offered to all who completed the test, and special prizes of smaller value to all who completed one or more rounds. The contest was a public affair, and was witnessed by a large gathering of people who lined the streets through which the contestants walked. A stand was arranged for the judges, and in every way provision seems to have been made to insure accuracy as regards entries, distance covered by each contestant, and so on.

Forty-eight men entered the contest. Of these 44 finished the first round, 25 the second round, 22 the third, 19 the fourth, 15 the fifth, 13 the sixth, 11 the seventh, 10 the eighth, 9 the ninth and 8 the tenth, while 6 completed the 12 rounds and fulfilled all the conditions of the contest.

The ages of the six successful contestants ranged from 21 to 52 years, four of them being 36 years old or over. Their body weight ranged from 150 to 255 pounds, the average being 189 pounds (86 kilograms). Of the 38 other contestants who completed one lap the ages ranged from 17 to 61 years, the majority being 30 years or over, while eight were over 40 years old. The body weights ranged from 120 to 200, being on an average 162.4 pounds (74 kilograms).

As shown by the account of the contest published in the Kankakee press, each of the six men who completed the course felt that he was in condition to continue for a longer distance, but this the management did not permit.

The men who entered the contest were residents of Kankakee and were of different nationalities, including Germans, Scandinavians, French Canadians, a Pole and a Turk, while, judging by the published list of names, about one third of them were Americans. The newspaper[1] under whose auspices the contest was held published a list of the winners, with names and addresses, and data regarding their age and weight, as well as a general description of the affair.

Through the courtesy of the editor of the paper, and by correspondence with a number of the contestants, including four of the six who completed the contest, additional data were secured, particularly with reference to the dietary habits of the men and their condition as regards training when they entered the contest. A circular letter of inquiry was sent to the successful contestants and to those

[1] *Kankakee Republican*, 1907, November 29, p. 1.

who completed one lap. Of the replies received four were from the successful contestants, and two from the group completing one lap, while one was unsigned and consequently the group to which the writer belonged is uncertain. It has seemed a fair assumption in discussing the results that he belonged to the larger group; that is, those completing one round and not the entire course. The circular letter made inquiry as to the number of meals eaten per day and as to whether the subject considered himself a medium, hearty or light eater, whether he was fond of athletics and kept in training, and whether his usual occupation involved any considerable amount of physical work. To obtain more specific data regarding the food, one of the questions was "Do you use all the ordinary foodstuffs and beverages such as are given in the following list? If there are any which you do not use, please cross them out." The list included bread, cereal foods, butter, milk, cheese, eggs, meat, vegetables, fruit, sugar, tea and coffee.

The majority of those who answered the questions considered themselves hearty eaters, and all habitually took three meals a day. One considered himself a medium hearty and one a light eater, while one did not specify.

As regards the ordinary foods included in the list, the answers received from the contestants show that, making allowance for some individual preferences, all these men lived on a mixed diet composed of the ordinary food materials, and it is probable that those who replied were fair representatives of the whole number participating in the contest. As regards individual peculiarities of diet, three of those who furnished information stated that they did not use cereal breakfast foods, and one that he used them only sparingly. One of the men ate little fruit except apples, and two used no cheese, while two used neither tea nor coffee and one other no tea.

In the case of the four winners of the contest it seems worth while to summarize in somewhat more detail the data furnished.

F. G., who was 24 years old and weighed 120 pounds (54 kilograms), stated that he was fond of athletics, and while enlisted in the Illinois National Guards had military training once a week. He also stated that he walked to and from work, one and a fourth miles, four times daily, and considered that a good deal of physical labor was required in his daily occupation as a shipping clerk in a retail grocery house, as goods had to be looked over, checked and handled, and the various baskets of goods sent out weighed on an average from 5 to 100 pounds. He used all of the foods mentioned but stated that only a little cereal breakfast food was used and that apples were the fruit commonly eaten.

C. H. C., whose age was 40 years and whose weight was 255 pounds (116 kilograms), stated that he used all the foods mentioned in the list, but that as regards vegetables, turnips and cabbage were only used raw, while onions were not eaten at all. He stated further that he had not engaged in any form of athletics since 18 years of age. He believed that his ordinary work involved considerable muscular labor, but further details were not given.

J. B., who was 52 years of age and who weighed 180 pounds (82 kilograms), stated that he did not engage regularly in any athletic exercises, but believed that considerable muscular work was required by his daily occupation. No further details were given on this point. As regards the character of his food, he stated that he used bread, cereal breakfast foods in limited quantity, butter, milk, cheese very sparingly, eggs, meat (mostly salt pork), vegetables, fruit, sugar, and both tea and coffee in limited quantity. A diet in which salt pork is the principal meat, with eggs, bread, fruit and vegetables would seem to resemble more closely than any of the others the diet which was once very characteristic of farms in many localities, but which is less common now than formerly, owing to a greater abundance of ice for keeping fresh foods and to improved methods of transportation and other modern conveniences. J. B., who was the oldest of the successful contestants, believed that he could have carried the load of 100 pounds for 15 miles.

G. H., the remaining successful candidate who supplied data, stated that he was 21 years

old and weighed 150 pounds (68 kilograms). He was not fond of athletics and did not keep in training, though he believed that his usual occupation involved a considerable amount of physical work. As regards food, he stated that he used bread, butter, cheese, eggs, meat, fruit and coffee, and that he did not use cereal foods, milk, vegetables, sugar and tea. He considered that he ate a medium amount, as distinguished from the other three successful contestants quoted, who stated that they were "hearty eaters."

Judging from the data summarized, it appears that although there were some individual peculiarities in the selection of food, all four of the successful contestants who supplied data used a mixed diet, made up of the ordinary food materials, and the same was true of the other three men who furnished information.

The question of energy expenditure in walking has been exhaustively studied under a variety of conditions by Zuntz and his associates. According to the data obtained by Zuntz and Schumburg[2] with soldiers marching on a level, the energy expenditure for motion of forward progression averages 0.52 calorie per kilogram of body weight per 1,000 meters. Practically the same figures for energy expended in walking on a level have been reported by Durig,[3] in his study of respiratory quotient and energy expenditure of men marching on a level, at low and high altitudes.

When consulted regarding the probable energy expenditure under the conditions of the Kankakee contest, Professor Zuntz stated that he was of the opinion that a special factor should be used for the load carried, and that not less than 0.6 calorie, perhaps even 0.7 calorie, per kilogram of load per 1,000 meters of distance covered would be a proper factor.

Taking into account the above-mentioned values, the calculated average energy expenditure of the six successful contestants would be 1,137 calories, of which 707 would represent the energy expended in moving 86 kilograms, the average body weight, over a distance of 15.8 kilometers, and 430 calories the energy expended in moving over this distance the load which was carried.

As regards the individuals who completed the entire course, the calculated energy expenditure for F. G., who weighed 54 kilograms, would be 874 calories, of which 444 calories represents the energy expended in moving the body over the course, and 430 calories that for the load. The energy expenditure for C. H. C., who weighed 116 kilograms, was calculated to be 1,383 calories, of which 953 calories represents the expenditure for the body, and 430 calories that for the load. For J. B., who weighed 82 kilograms, the calculated energy expenditure would be 1,104 calories, 674 calories representing the expenditure for the body and 430 calories that for the load. G. H. weighed 68 kilograms, and in his case the energy expended in carrying the load over the full course would be 989 calories, of which 559 calories represents the expenditure for the body, and 430 calories the expenditure for the load.

In the case of the 38 other men, with an average weight of 73.8 kilograms, who completed one lap in the contest, the calculated energy expenditure would be 84 calories, of which 49 calories represented the energy expended for forward progression of the body, and 35 calories the energy expenditure involved in carrying the load.

Thirteen men completed half the course. Assuming that their average body weight was the same as the average for all the men who completed one round, namely, 75 kilograms, the calculated average energy expenditure would be 523 calories, of which 308 calories represents the expenditure for moving the body over the course, and 215 calories represents the energy expenditure for moving the load.

Like most towns in the middle west, the streets of Kankakee are comparatively level. However, in the account quoted it is stated that there is a grade of about 9 feet per hun-

[2] "Physiologie des Marsches," Berlin, 1901, p. 299.

[3] *Denkschriften der Mathematisch-Naturwissenschaftlichen Klasse der Kaiserlichen Akademie der Wissenschaften*, 86 (1909), pp. 242–291.

dred on one of the streets over which a part of the course was laid. This, if it constituted any large part of the whole, would naturally increase the work performed, but apparently the greater part of the course was over streets with very little grade.

Since accurate data regarding the grade of the entire course are not accessible, it has seemed best to compute the results in detail without trying to take it into account. The organizers of the contest were of the opinion that the grade mentioned made the 10-mile course equivalent, in its demands upon the men, to a level course of 15 miles. If such an assumption be made, it would mean an average energy expenditure of 1,706 calories for those who completed the test.

As a result of the Department of Agriculture experiments with the respiration calorimeter, it has been calculated that a man at ordinary work, such as that of a mason or a carpenter, expends in the performance of his daily work, at least 1,200 calories. This means that the average energy expenditure of the man in performing the work of a contest which lasted four hours was greater than the above value for a day's work.

From a single test and so limited data it would be manifestly unfair to draw sweeping deductions regarding the character of the food in its relation to endurance. It is nevertheless a fact that the four successful candidates who furnished data lived on the ordinary mixed diet of the average citizen, and from all the information collected the same was true of all who entered the contest. This contest is of interest on this account and also because the endurance feat undertaken is comparable with the ordinary forms of muscular work which pertain to usual vocations, and so may be fairly considered as furnishing some indication of the fitness of the subjects for successfully engaging in occupations involving manual labor.

The total number completing the trial of strength is small (6 out of 48) in proportion to the total number of entries, but the number (44) of those who carried the 100-pound weight for nearly one mile is large, while it was not until the men had passed the judges' stand four times that the number of contestants dropped below 20.

It seems fair to conclude that the men who engaged in the contest were, as regards their food, their occupation and their general living conditions, representative of the very large group of our population who are living comfortably and meeting their daily obligations in a creditable manner, who are, in fact, living the average life of the average man, with its varied activities and interests.

In so far as the recorded data throw light on the subject, they indicate that the average man living the average life is capable of meeting body demands of considerable severity—a conclusion which perhaps few would question, but which it is interesting to consider in the light of numerical data.

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THE USE OF ACID SOIL FOR RAISING SEEDLINGS OF THE MAYFLOWER, EPIGAEA REPENS

MAYFLOWER or trailing arbutus (*Epigaea repens*), probably the best beloved of all the wild flowers of the eastern United States, is rarely seen in cultivation. It usually does not survive transplanting. No evidence has yet been found that flowering plants have ever actually been raised from the seed.

The development of a system of cultivating the swamp blueberry (*Vaccinium corymbosum*), by the use of acid soils,[1] suggested that a similar method might succeed with trailing arbutus, because the two plants have the same natural habitat, and because a symbiotic root fungus similar to the beneficial and probably indispensable root fungus of the blueberry was found to occur on trailing arbutus.

Seeds were procured in New Hampshire in July, 1909. They were sown in a mixture of kalmia peat, sand, and sphagnum. They germinated in August. After successive trans-

[1] "Experiments in Blueberry Culture," 1910 (Bulletin 193, Bureau of Plant Industry, Department of Agriculture).

plantings in an acid soil consisting of nine parts kalmia peat, by bulk, and one part clean sand, the plants in August, 1910, began to form their flowering buds. The larger plants then more than filled a five-inch pot. They were left outdoors during the winter, were brought into a cool greenhouse in March, and in a few days were in full flower. The plants were remarkably beautiful. The flowers had the characteristic color and fragrance of wild ones and were of unusual size, the largest corolla having a spread of seven eighths of an inch. The foliage was free from insect and other injuries to an extent seldom seen in wild plants.

Plants kept in a greenhouse all winter flowered only sparingly, but they furnished an opportunity for the observation of the fruit. The fruit of trailing arbutus is described in our standard works as a loculicidal capsule, but this description is incorrect, and must have been based on an erroneous deduction from immature specimens or imperfect remnants. The fully mature fruit is not a dry pod. It is as juicy as a strawberry. Its style of dehiscence is not loculicidal, but is that exactly if not melodiously described as "septicidally or rather marginicidally septifragal." In examples of perfect development the wall of the fruit while still green and herbaceous splits along the cell partitions into five valves, which spread backward into a five-pointed rosette, exposing the white, fleshy, succulent interior with the minute brown seeds dotted over its surface. The fleshy part, which looks like an unripe strawberry and is about a quarter of an inch in diameter, consists of the whole interior of the fruit, axis and dissepiments as well as placentæ. These observations as to the character of the fully developed fruit confirm the original observations made in New Hampshire in late July, 1909, at the very end of the fruiting season.

Frederick V. Coville

SOCIETIES AND ACADEMIES

THE TORREY BOTANICAL CLUB

The meeting was held at the American Museum of Natural History. The meeting was called to order at 8:15 P.M., with Dr. E. B. Southwick in the chair. Twenty-eight persons were present.

The scientific program consisted of a lecture on "Orchids, Wild and Cultivated," by Mr. Geo. V. Nash. The lecture was illustrated by a large number of beautiful lantern slides. An abstract of the lecture prepared by the speaker follows:

By the general public any odd or strange flower was considered an orchid, and as an illustration of this common error nepenthes and bromeliads were cited. The large division of endogenous plants to which the orchids belong was illustrated with a slide of the lily, this being taken as typical. Especial attention was called to the stamens and pistil which are distinct in this flower. As an illustration of a typical orchid flower a slide of *Cattleya* was shown. The uniting of the stamens and pistil into one organ, known as the column, was pointed out as the distinctive character of the orchid.

Another interesting feature is the diversity of the lip form. The lip is one of the petals. In some forms, such as *Odontoglossum*, it much resembles the other petals. In *Oncidium* it is markedly different in size and color; in *Cattleya* it becomes more modified by the inrolling of the base into a tube which surrounds the column; in *Dendrobium* a still greater modification occurs in the inrolling of the margins of the lip into a saccate organ; and in *Cypripedium* this tendency is greatly magnified, giving us the "slipper."

The stem or leaves of orchids are frequently thickened, thus serving as storage organs for water. The water supply of many orchids, on account of the habitat on trees and rocks, is very uncertain, and those thickened leaves or stems carry the plants safely through periods of drought. When the thickened stems are short, and round or oval, they are known as pseudobulbs.

Some orchids grow in the ground and are known as terrestrial. These are commonly found in temperate regions, where dangers from frost exist. The majority, however, are epiphytic, that is, they grow on trees, and are found in warm temperate and tropical regions. The number of species is between 6,000 and 7,000, of which about 150 are found in the United States. The two great centers of their occurrence are: in the new world, in northern South America, northward into Central America, and in the west Indies; in the old world, in India and the Malay region. A series of slides was then exhibited illustrating some of the common wild and cultivated forms.

B. O. Dodge,
Secretary